Takeda Riken Co., Ltd.

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INSTRUCTION MANUAL

TR 4172

Spectrum Analyzer

VOL.－1

MANUAL NUMBER 0069 ES 410

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SECTION 1

GENERAL INFORMATION

1-1. GENERAL

The TR4172 Spectrum Analyzer is a microprocessor-controlled, intelligent instrument with a frequency range from 50 Hz to 1800 MHz.

In addition to the spectrum analyzing function, the integrated tracking generator of TR4172 enables analysis of frequency response of filters, amplifiers, and so on.

TR4172 is the first spectrum analyzer with a capability for measuring phase response and group delay of filters or amplifiers at resolutions of down to 0.1 deg and 0.1 ns respectively, up to a frequency of 1800 MHz.

The integrated tracking generator, along with the analyzer's intelligent control capability, permits correction of the analyzer's frequency response itself allowing precision level measurement.

A wide dynamic range is ensured by the low higher-harmonic distortion level of -90 dB at and above 20 MHz, with respect to a signal level of -40 dBm.

The display screen has a dynamic range of more than 95 dB and permits direct observation of filter responses with large attenuations.

The vertical resolution of the scale can be selected from 10, 5, 2, 1, and 0.1 dB per division. Observation of a ripple level of even 0.01 dB is possible with the maximum resolution setting.

Use of the SAVE switch makes various measurements available, with which up to eight sets of measurement condition data are stored in the internal registers and recalled as needed. Since the internal memory is backed up by a battery, its contents remain intact even if the device is unplugged from its supply outlet.

All front panel functions are remotely controllable with the GP-IB interface (standard supply) for automatic measurement.

The CRT display presents all pertinent measurement data. The signal response trace and measurement data on the screen can be output to an X-Y plotter simply by connecting the instrument's GP-IB connector to the plotter's input with a GP-IB cable and operating the relevant front-panel switches, without the need for running an output program on the GP-IB controller.
TR4172 also provides various convenient features to enhance measurement flexibility and efficiency, such as multiple marker, zoom, automatic centering, automatic enlargement, auto-peak search, logarithmic scaling, and four page memorized display.

1-2. FEATURES

(1) Spectrum, amplitude, phase and group-delay measurement capability at resolutions of down to 10 Hz, 0.1 dB/div., 0.2 deg/div., and 0.1 ns/div. respectively.
(2) Wide dynamic range of 90 dB at -40 dBm input level (above 20 MHz).
(3) CRT screen with a large display dynamic range of more than 95 dB permitting direct observation of large attenuation responses.
(4) Simultaneous four trace display allowing waveform comparison.
(5) Multiple marker.
(6) Automatic correction of bandwidth switching error, step amplifier switching error, and frequency response error.
(7) Scaling the horizontal graticule divisions in logarithmic scale.
(8) Output to an X-Y plotter supported without the need for the external GP-IB controller.
(9) Remote operation of all front panel functions via the external GP-IB interface facility (standard supply).
Reading capability for measurement data and labels on the screen and writing capability for characters and data on the screen.

1-3. ACCESSORIES SUPPLIED

The standard accessories supplied with the instrument are listed below. Check the quantity and specifications of the accessories against this listing:

(1)	Fuse	MDX-1A	2
(2)	Fuse	MDA-1.25A	2
(3)	Fuse	EAWK 0.2A	2
(4)	Fuse	EAWK 0.1A	4
(5)	Fuse	MF51NR1 (250)	4
(6)	Fuse	MF51NR2 (125)	8
(7)	Fuse	MF51NR-2.5	2
(8)	Fuse	MF51NR-5	2
(9)	Allen wrench	3 mm	1
(10)	Input cable	MI-02 (UG-88/U plug, BNC-BNC)	2
(11)	Input cable	MI-04 (UG-21D/U plug, N/N)	2
(12)	Input cable	MC-61 (UG-88/U plug, BNC-BNC)	1
(13)	N to BNC plug adaptor	JUG-201A/U	2
(14)	BUS cable		1
(15)	RF interconnecting cable		1
(16)	IF interconnecting cable		1
(17)	Power cable		2
(18)	Instruction Manual		1

1-4. SPECIFICATIONS

FREQUENCY SPECIFICATIONS

Frequency range : 50 Hz to 1800 MHz
DC coupled: 50 Hz to 1800 MHz
AC coupled: 10 kHz to 1800 MHz

Frequency span : 100 Hz to 1800 MHz on 10 divisions of the CRT horizontal axis graticule.
Enterable with the DATA knob or DATA number/unit keyboard in two significant figures.
Controllable with the DATA step keys in a 1, 2, or 5 steps.
At zero frequency span mode, the analyzer functions as a fixed tuned receiver.

Frequency span accuracy: Better than ±3% for span > 500 kHz.
Better than ±5% for span ≦ 500 kHz.

Center frequency : 0 Hz to 1800 MHz variable with the DATA knob, DATA step keys, or DATA keyboard.
The center frequency can also be set with the MKR → CF or SIGNAL TRACK key.
Center frequency step size can be controlled with the CF STEP SIZE or MKR/Δ → STEP SIZE key.

Center frequency accuracy: ±(1% of frequency span + 20 Hz)

Marker

NORMAL : Provides direct frequency readout of the marker point.
Accuracy: Center frequency accuracy plus frequency span accuracy between the marker and center frequencies.

T.G. CNTR : Provides direct readout of the marker frequency.
Accuracy: Equal to the center frequency accuracy.

FREQ. CNTR : Provides direct readout of signal frequency the level of which is more than +15 dB higher than the noise level.
Accuracy: (Master oscillator accuracy) x (frequency readout) ± (2 counts) for signal frequencies from 400 kHz to 1500 MHz.

Reference Oscillator Stability:

	A Type	B Type	C Type
Aging Rate	5×10^{-9}/day	2×10^{-9}/day	5×10^{-10}/day
Temp Stability ($0^{\circ}C$ to $40^{\circ}C$)	5×10^{-8}	1×10^{-8}	5×10^{-9}

SIGNAL TRACK : Maintains a drifting signal and the marker at the center of the display.

Δ(delta) : Provides direct readout of a frequency difference between two markers.

ZOOM : With use of the DATA step key, $\boxed{\downarrow}$, reduces the frequency span while centering the marker.

Resolution

Resolution bandwidth (3 dB bandwidth): 10 Hz to 1 MHz in a 1-3 sequence.

Bandwidth accuracy: ±20%

60/3 dB resolution bandwidth ratio:
10:1 in 1 MHz, 300 kHz
13:1 in 100 kHz to 10 Hz

Stability

Residual FM component: 2 Hz p-p/1 sec or less; frequency span 50 kHz

Frequency stability: 30 Hz p-p/min.; frequency span 50 kHz (at a constant temperature after 1 hour of warm-up)

Noise sideband : -75 dB or less at 20 kHz apart from the carrier, with resolution bandwidth of 1 kHz and video filter bandwidth of 1 Hz.
-80 dB or less at 30 kHz apart from the carrier, with resolution bandwidth of 1 kHz and video filter bandwidth of 1 Hz.

AMPLITUDE SPECIFICATIONS

Measurement range : -130 dBm to +20 dBm

Display range : Logarithmic scale (with respect to the reference level): 95 dB at 10 dB/div.
50 dB at 5 dB/div.
20 dB at 2 dB/div.
10 dB at 1 dB/div.
0.8 dB at 0.1 dB/div.

Linear scale (calibrated in voltage):
10%/div. of the reference level at LIN x 1
5%/div. of the reference level at LIN x 2
2%/div. of the reference level at LIN x 5
1%/div. of the reference level at LIN x 10

Linearity

Logarithmic : ±0.2 dB/1 dB over 0 dB to 95 dB
Max. ±1 dB over 0 dB to 95 dB ($20^{\circ}C$ to $30^{\circ}C$)
Max. ±1.5 dB over 0 dB to 95 dB ($0^{\circ}C$ to $40^{\circ}C$)

Linear : ±3% of the reference level

Reference level

Reference level readout:

Logarithmic:

+50.0 dBm to -90.0 dBm (readout in units dBμV)

Linear: 70.7 V to 7.07 μV

Reference level readout accuracy: Max. ±1 dB after calibration and error correction

Calibration output accuracy: -20 dBm ±0.3 dB (Guaranteed at the CAL. OUT. connector)

(50 MHz) ± (50 MHz x reference oscillator accuracy)

Frequency response: Within ±0.7 dB over 400 KHz to 1500 MHz (after error correction)

Marker

NORMAL : Provides readout of the amplitude at an active marker.

PEAK SEARCH : Positions the marker to the peak of the largest signal.

MKR → REF : Brings the reference level equal to the marker level.

△ (delta) : Provides readout of the level difference between two markers.

Multiple marker points: Up to 10 points

DISPLAY LINE : A horizontal display line traces amplitude readout.

Dynamic range

Spurious response : -80 dB or less at -30 dBm input with center frequency ≧ 20 MHz

-60 dB or less at -30 dBm input with center frequency < 20 MHz

Average noise level: -130 dBm or less at a resolution bandwidth of 10 Hz, video filter bandwidth of 1 Hz, and center frequency of 1 MHz or above

Residual response : -100 dBm or less

Gain compression : 1 dB or less at 0 dBm input

SWEEP SPECIFICATIONS

Sweep time : 50 ms to 1000 sec

100 μs to 1000 sec at zero frequency span mode

Trigger mode : INTernal, LINE, EXTernal, VIDEO, and SINGLE

INPUT SPECIFICATIONS

RF input	: N type connector, 50 Ω
Maximum input level	: +20 dBm (Input attenuator 20 dB or more) DC coupled: max. 0 VDC AC coupled: max. ±25 VDC
Input attenuator	: 0 to 50 dB attenuation at 10 dB step

DISPLAY SECTION SPECIFICATIONS

Display	: Graticule, waveform, measurement data, and label
Trace	: 4 trace memories for traces A, B, A', and B' When trace memories A and B are used, the number of data points on the horizontal graticule is approx. 1000, and vertical resolution is 0.1%. When trace memories A' and B' are used, the number of data sampling points on the horizontal graticule is approx. 500. Contents of the memories are displayed at a rate independent of the analyzer sweep rate.
WRITE mode	: Analyzer's response is stored and displayed for each sweep.
MAX HOLD mode	: Stores and displays the maximum signal level at each horizontal point.
VIEW mode	: No updating of the trace memory is made, and the stored memory data is displayed.
BLANK mode	: No updating of the trace memory is made, and the trace data are not displayed on the CRT but are stored in the memory.
Trace Arithmetic	
A-B → A	: Trace B amplitude is subtracted from trace A and the result is written into trace A from sweep to sweep.
A ⇄ B	: Exchanges traces A and B, changing their relative intensities and storage memory locations. Traces A' and B' are also exchanged.
B-DL → B	: Display line level is subtracted from trace B and the result is written into trace B.
CRT Display	
Screen size	: 100 mm x 124 mm (P31 phosphor)

TRACKING GENERATOR

Frequency range : 400 kHz to 1800 MHz

Output level : 0 dBm to -50 dBm at 10 dB step

Output level accuracy: Within ±1 dB at center frequency of 50 MHz

Spurious : Less than 20 dB

Output connector : N female

Output impedance : 50 Ω, VSWR 1.5 or less (with ATT set at 10 dB or more)

Frequency response: Within ±1 dB

Tracking drift : Less than 30 Hz/min, Less than 300 Hz/10 min

PHASE MEASUREMENT

Frequency range : 400 kHz to 1800 MHz

Range : 80°, 40°, 20°, 8°, 4°, 2°, 0.8°, 0.4°, and 0.2° per division

Offset : Up to $\pm 250^\circ$

Measurement range : $\pm 180^\circ$

Resolution : 1/10 or more of /div.

Accuracy : Better than ±3% $\pm 0.25^\circ$ (after calibration)

Residual phase : Less than 100° p-p (with span set at 500 MHz or less, and input ATT. set at 10dB or more)

GROUP DELAY MEASUREMENT

Frequency range : 400 kHz to 1800 MHz, 0 ms to 100 ms

Range : $16 \times \frac{1}{\text{frequency span}}$ to $\frac{1}{200} \times \frac{1}{\text{freq. span}}$ (sec/div.)

Measurement range : 160 ms/div. to 100 ps/div.

Resolution : $\frac{1}{50} \times \frac{1}{\text{frequency span}}$

Maximum resolution: 0.1 ns

Electrical length correction range: $8 \times \frac{3 \times 10^8}{\text{freq. span}}$ meters or more

Measurement accuracy: phase measurement accuracy ± span accuracy

GENERAL SPECIFICATIONS

Operating temperature: 0°C to $+40^\circ$C RH Less than 85%

Storage temperature : -20°C to $+60^\circ$C

Power requirements: 100, 120, 220 V (±10%), 240 V (+4%, -10%): 50/60 Hz approx. 300 VA

Probe power supply: ±15 V, 4-pin connector

Dimensions : Approx. 424(W) x 311(H) x 550(D) mm

Weight : Less than 50 kg

1-5. OPTIONS AND OPTIONAL ACCESSORIES

The following options and accessories are available for the TR4172 Spectrum Analyzer. Factory options should be ordered when ordering the analyzer.

1-5-1. Options

- X-Y recorder output (option 03: factory option)
  X output: 0 V to approx. +5 V
  Y output: 0 V to approx. +5 V
  Z output: 0 V to approx. +5 V
- Preamplifier (option 02: factory option)
  Frequency range: 10 MHz to 1000 MHz
  Gain: 25 dB or more
  Flatness: Better than ±3 dB
- QP (quasi peak) detection mode (option 01: factory option)
  Display dynamic range: 70 dB
  (1) Frequency range: 10 kHz to 150 kHz
      Charging time constant: 45 ms ±20%
      Discharging time constant: 500 ms ±20%
      Display time constant: 160 ms ±20%
      Selectivity: 200 Hz ±20 Hz (at Bandwidth of 6 dB)
  (2) Frequency range 150 kHz to 300 MHz
      Charging time constant: 1 ms ±20%
      Discharging time constant: 160 ms ±20%
      Display time constant: 160 ms ±20%
      Selectivity: 9 kHz ±1 kHz (at Bandwidth of 6 dB)
  (3) Frequency range 25 MHz to 1000 MHz
      Charging time constant: 1 ms ±20%
      Discharging time constant: 550 ms ±20%
      Display time constant: 100 ms ±20%
      Selectivity: 120 kHz ±20 kHz (at Bandwidth of 6 dB)

* Impedance measurement option (Option 05: factory option)
  The impedance measurement option is designed for use with the impedance measurement standard accessory.

Specifications of Mainframe Options

Functions:

Smith chart display: Standard Smith chart
Mangified (x10) Smith chart
Polar coordinate display

Marker display: Provides direct readouts for VSWR, reflection coefficient, phase, normalized impedance, and equivalent inductance or capacitance.

Display circle: Displays an arbitrary circle representing a VSWR or reflection coefficient on the Smith chart.

Open/short auto correction: When an open or shorting plug is attached, amplitude or phase can be calibrated to impedance and the 0 points on a Smith chart, (recommended when the frequency span setting is 500 MHz or below).

Specifications

Smith chart scale:

Standard Smith chart: Real part: 0, 0.2, 0.5, 1, and 2
Imaginary part: 0, ± 0.2, ± 0.5, ± 1, ± 2

Magnified Smith chart: Real part: 0.9, 1.0, 1.1, and 1.2
Imaginary part: −0.1, 0, and 0.1

Polar coordinate scale:

Amplitude: 20% divisions of the fullscale

Phase: 30° division

Display resolution:

Amplitude: 1/500 of the distance between the center of the Smith chart and its fullscale

Phase: 1°

Frequency division: 1/500 of the selected frequency span (variable to 1/16)

Marker point resolution:

Amplitude: 1/500 of the distance between the center of the Smith chart and its fullscale

Phase: 1°

Frequency division: 1/500 of the selected frequency span

Marker readout resolution:

VSWR: 3 digits

Reflection coefficient: 3 digits

Phase: 1°

Normalized impedance: 3 digits

Equivalent inductance: 3 digits

Polar coordinate display resolution: 1/500 of the distance between the center and fullscale.

Polar coordinate display accuracy: True value is within a circle with a radius of 1 mm and its center placed at the displayed value.

Display circle resolution: 1/500 of the distance between the center and fullscale.

Amplitude information acquisition: From mainframe basic mode (LIN x 1)

Phase information acquisition: From mainframe basic mode 40°/div.

Amplitude setup on the Smith chart fullscale: 0.1 dB steps

Open/short auto correction range:

Amplitude correction range: Between fullscale and 70% of fullscale

Phase correction range: $\pm 180^{\circ}$

Note: Option 05 cannot be installed on the TR4172 with the X-Y Recorder Output option (Option 03).

- Occupied bandwidth display (option 04: factory option)
  Trace data is divided into 1001 points to calculate power at each point. Two markers appear at the positions where 0.5% to the total power is determined from leftmost and from rightmost points respectively, and then frequency between two markers is displayed at the active function area on the left side of CRT.
- Adjacent channel leakage power arithmetic operation software (option 06: factory option)
  Trace data is divided into 1001 points to calculate power at each point. The power equivalent to the width specified by the delta marker is calculated, and the ratio of the calculation result to the total power is displayed. In addition, the power equivalent to the width specified by the delta marker is integrated, and integration trace is also displayed.
- X-Y plotter interface (option 07: factory option)
  Trace data, graticule line, and character are plotted by the following three plotters in papers of size 210 mm x 295 mm.
  [Applicable plotters]
  Model 9872A/7470A/7225A (Manufactured by Hewlett Packard)

1-5-2. Accessories

* Photographing system
(1) Camera (M75D) + close-up device (5R-32) + attachment (K-71R)
(2) Camera with hood (M085D) + attachment (#85-27)
*Standard impedance measurement accessories
(1) Directional bridge (60NF50)
(2) Standard cable (DGM010-00150EE): 2
(3) Open/shorting plugs for calibration (22N)
(4) Standard 50-ohm terminator (26N50)

SECTION 2

PREPARATION AND GENERAL PRECAUTIONS

2-1. INTRODUCTION

This section describes the general handling procedure for the TR4172 Spectrum Analyzer-preparation, general precautions and storage method. To ensure proper operation of the analyzer read the following instructions carefully.

2-2. UNPACKING

After unpacking, carefully inspect the instrument for any transit damage, paying special attention to the panel switches, CRT display, and terminals.
If the instrument is damaged or fails to operate properly, immediately notify your nearest Takeda Riken representative.

2-3. REPACKING FOR SHIPMENT

Should it become necessary to repack the instrument for shipment, use the original packing material or equivalent.

2-4. OPERATING ENVIRONMENT

(1) The instrument should be placed in a position where it will not be exposed to direct sunlight, corrosive gas, or excessive dust. The operating ambience should be $0^{\circ}C$ to $+40^{\circ}C$ in temperature, and not more than 85% in relative humidity.

(2) Ventilation
The instrument uses two exhaust cooling fans. Be sure to allow a space of more than 10 cm behind the instrument for adequate ventilation. Do not place the instrument on its side or back.

(3) Although the analyzer is protected from line noise interference, the local line noise environment should be considered. If excessive noise is expected, use a line noise filter in the primary circuit.

(4) The operation site should be free of excessive vibration.

(5) The storage temperature range is from -20°C to +60°C.
If the instrument is to be left unused for a long period of time, cover it with a vinyl cloth or put it in a carton for storage in a dry place where it will not be exposed to direct sunlight.

2-5. CLEANING CRT DISPLAY

Clean the surface of the CRT screen and filter at regular intervals with a soft cloth dampened with alcohol.
Never use any chemical solvent other than alcohol for cleaning.
Remove the filter in the following procedure. (Refer to Figure 2 - 1.)

① Remove the belt cover with a screwdiver.
② Remove two screws from the CRT upper panel.
③ Remove two screws from the CRT bezel adapter.

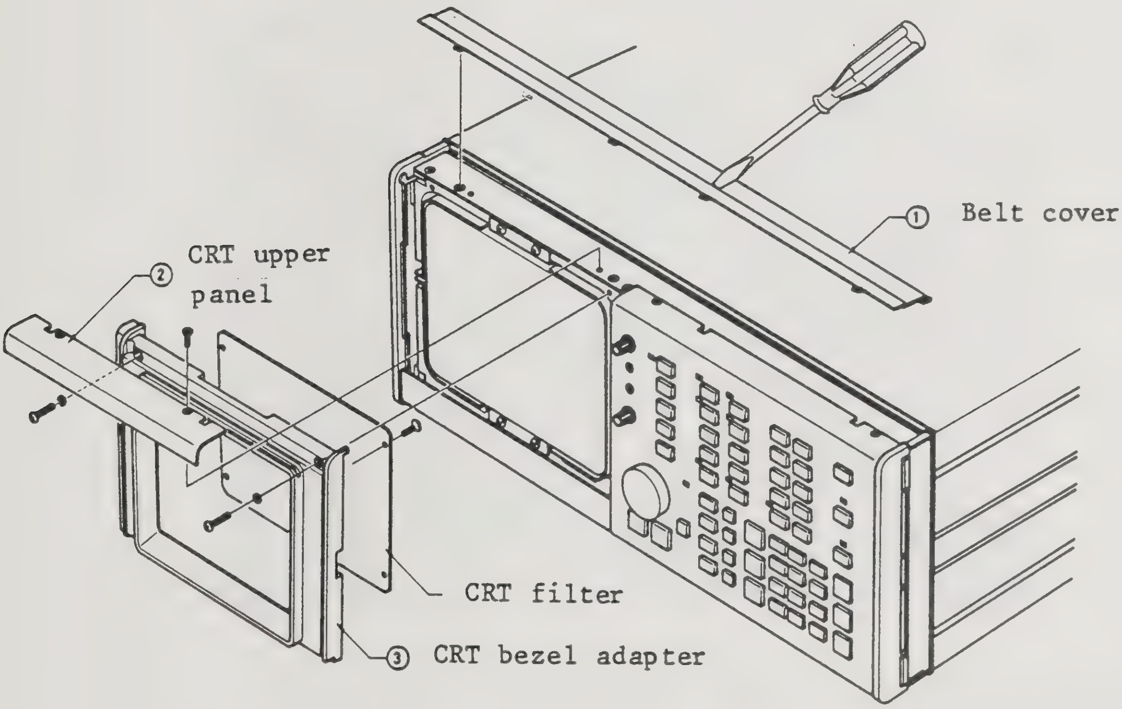


Fig. 2-1 Removal of CRT filter

2-6. PREPARATION

2-6-1. Connecting Display Section and RF Section

The analyzer consists of a display section and an RF section. Follow the procedure given below to assemble the two sections:

(1) Mount the display section (with CRT) directly on the RF section.

(2) Pull the display section forward until the joints engage with each other.

(3) Push back the display section until the front surfaces of the two sections are aligned. Using a coin edge, fasten the two joint screws at the rear corners of the instrument.

(4) Make electrical connections between the two sections with the three supplied interconnecting cables.

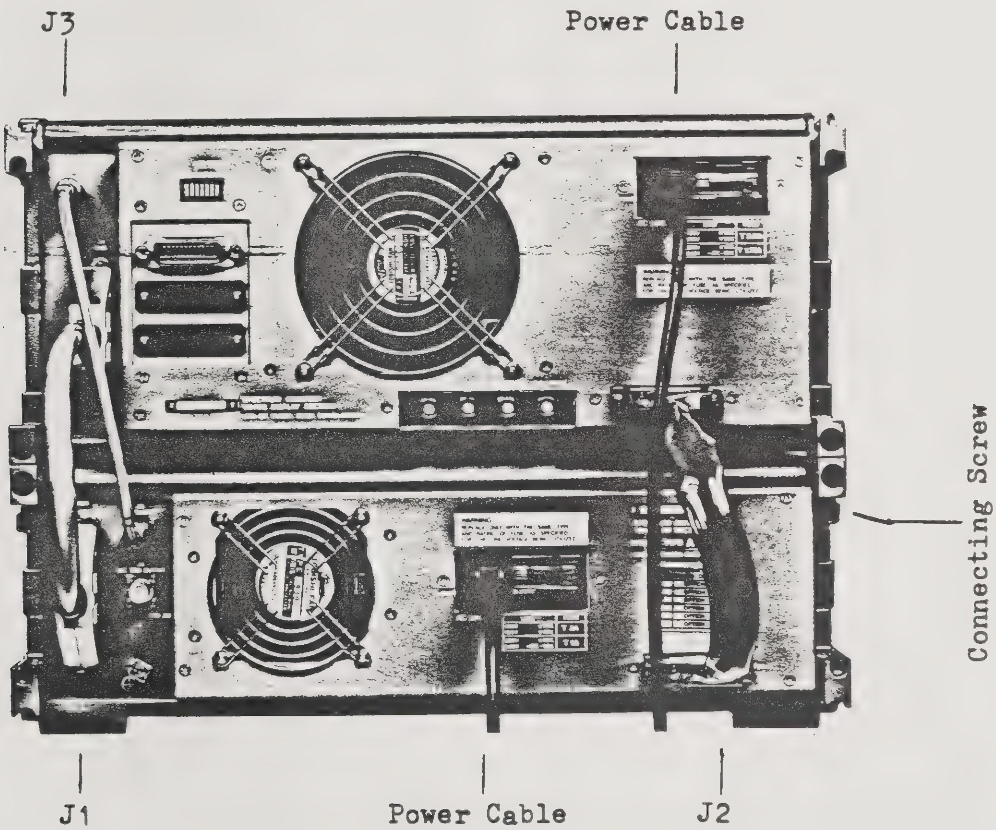


Fig. 2-2 Power and signal connections on the rear panels

(5) Three signal connectors J1, J2, and J3 are provided on the rear panels of each section. Connect them with their own interconnecting cables (J1 to J1 and so forth).

(6) Use the stopper and the connecting screw, when connecting J1 and J2 connectors, respectively.

2-6-2. Power Connection and Fuse

After establishing the signal connections between the two sections, make power connections to each section with the supplied power cables:

(1) Make sure that the POWER push switch on the RF section is in the STANDBY (out) position.

(2) An AC LINE connector is provided on the rear panel of each section. Plug the female side of the supplied power cables into each of these AC LINE connectors. (See Figure 2-2.)

(3) The male power plug at the other end of the power cable has three conductors, the center round conductor being the ground. (See Figure 2-3.)
When the available AC outlet has no ground receptacle, use the supplied plug adapter for power connection. In this case, make sure to connect the ground lead of this adapter or the rear GND terminal of the instrument to the earth ground.

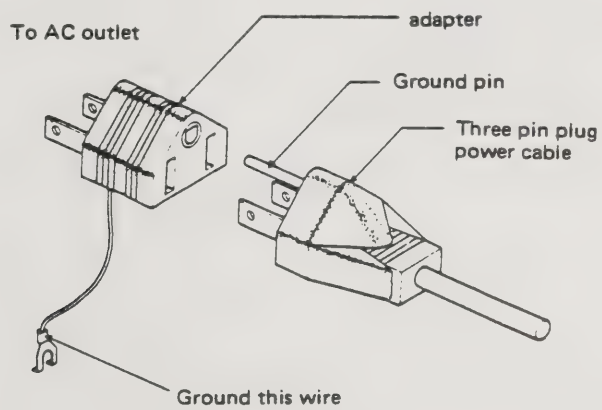


Fig. 2-3 Power cable and plug adapter

(4) When the instrument is plugged into an electrical outlet, the STANDBY indicator lamp on the front of the RF section will come on to indicate that the thermostatic oven for the internal master crystal oscillator is energized.

CAUTION

The instrument is partially energized even if the POWER switch is in the STANDBY position, as far as at least one of the power cables is connected to an electrical outlet. To completely turn off the instrument, be sure to disconnect both power cables from their electrical outlets.

(5) When replacing the fuse, unplug the power cable from the rear AC LINE connector of the pertinent section. Then, side the clear plastic cover of the fuse box to the left stop. Pull the FUSE PULL lever forward to remove the fuse from the fuse box. The replacement fuse must follow the ratings of (Table 3-1). Line voltage setting can be changed by a voltage setting card inserted just below the fuse holder. When you have removed the fuse, you will see the voltage setting card just below the FUSE lever.

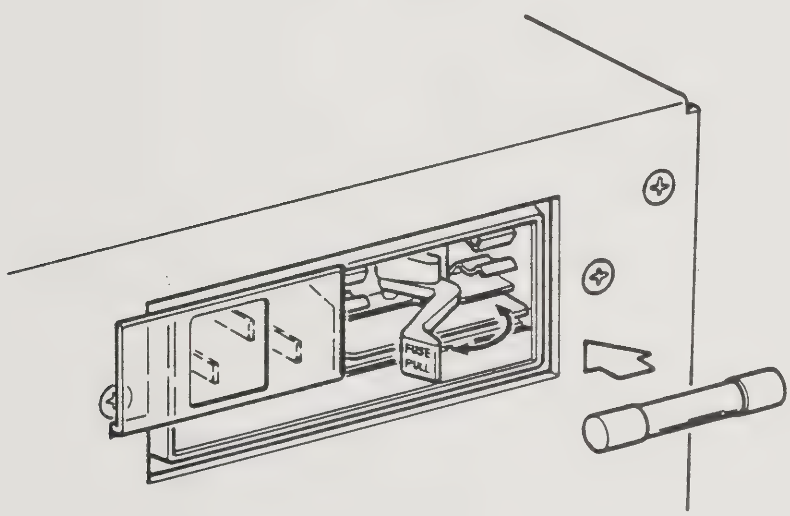


Fig. 2-4 Fuse replacement

Pull out the card and you will see voltage labels of 100 V, 120 V, 220 V , and 240 V on both sides of the card. Insert the card again into the card slot so that the voltage label corresponding to your local line voltage is on the top left side. You can see only the selected voltage label when the card is inserted in position.

The rating of the fuse to be used depends on the local line voltage. Check the fuse rating against the following table and replace it if needed:

Table 3-1 Fuse ratings versus line voltages

	Display section (upper)	RF section (lower)
AC100 V AC120 V	2.5 A slow blow	2.0 A slow blow
AC 220V AC240 V	1.25 A slow blow	1.0 A slow blow

2-7. USE OF PHOTOGRAPHIC EQUIPMENT

Assemble the close-up photographic equipment as illustrated in Figure 2-6. Photographic conditions differ depending on the setting of the INTENSITY control of the TR4172.

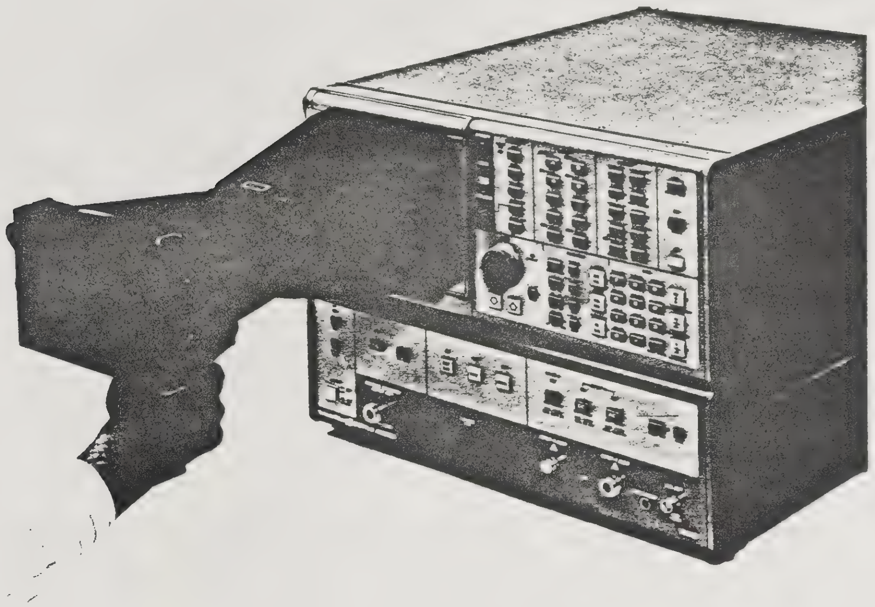


Fig. 2-5 Use of photographic equipment

Note: When the CRT display or the filter is not clear, clean photographs are not available. In this case, clean the screen and the filter referring to the subsection 2-5.
The film tends to get stuck if the roller inside the back plate becomes grimy. Take the roller out occasionally and clean it down.

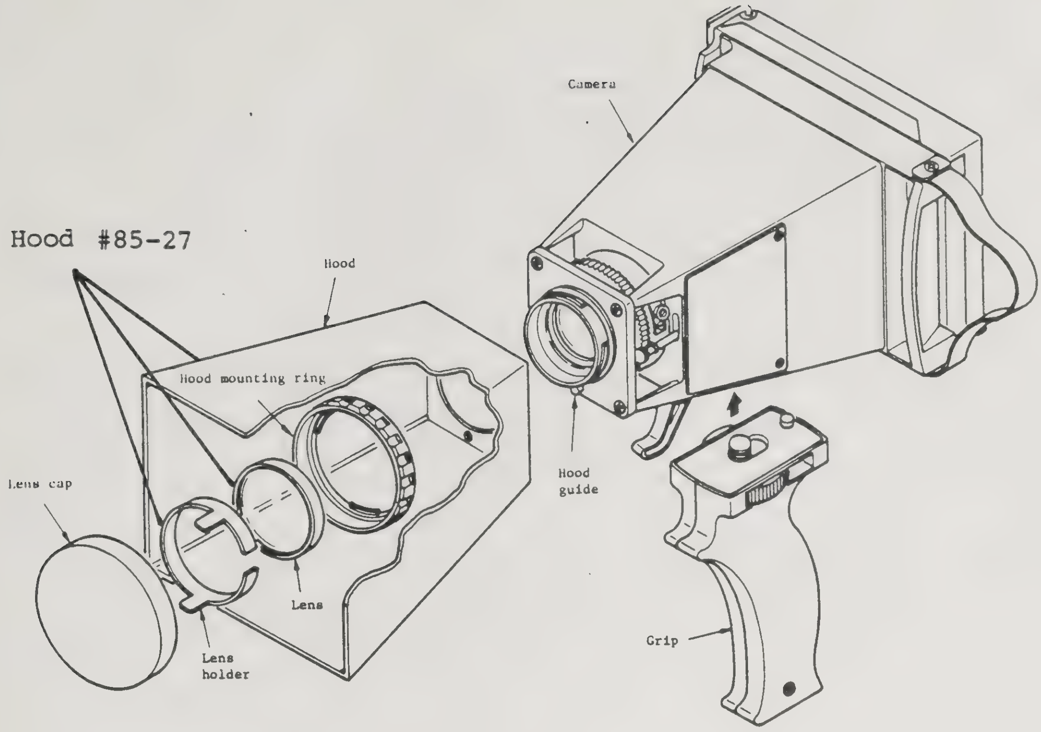


Fig. 2-6 Polaroid camera M-085D and Hood #85-27

SECTION 3
PANEL DESCRIPTION

3-1. INTRODUCTION

This section first describes basic operating procedures for the TR4172 Spectrum Analyzer and then presents the functions and setting ranges of each switch and control. Each function will be discussed in detail in Section 4.

Operating details for the tracking generator, phase measurement, and group delay measurement are described in Section 5, 6, and 7 respectively.

3-2. OPERATING PROCEDURE

The analyzer's CRT display presents direct readout of the center frequency, reference level (level at the top graticule of the CRT), and so forth, as well as signal response trace and graticule display. The operation of the analyzer consists basically of setting various measurement functions with the front panel controls and key switches and observing the resulting signal response trace and data readouts on the CRT for analysis.

When the analyzer is initially switched on (POWER switch set to ON) or the MASTER RESET switch is pressed during operation, the measurement functions on the CRT display are initialized into the following state:

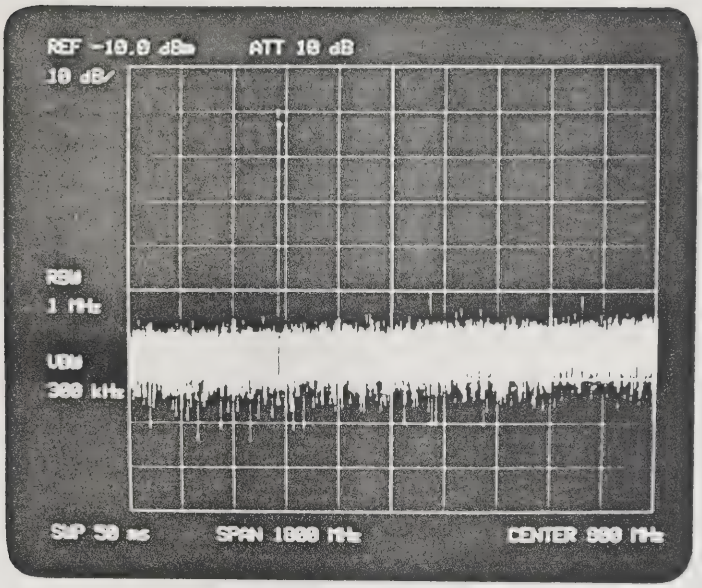
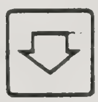
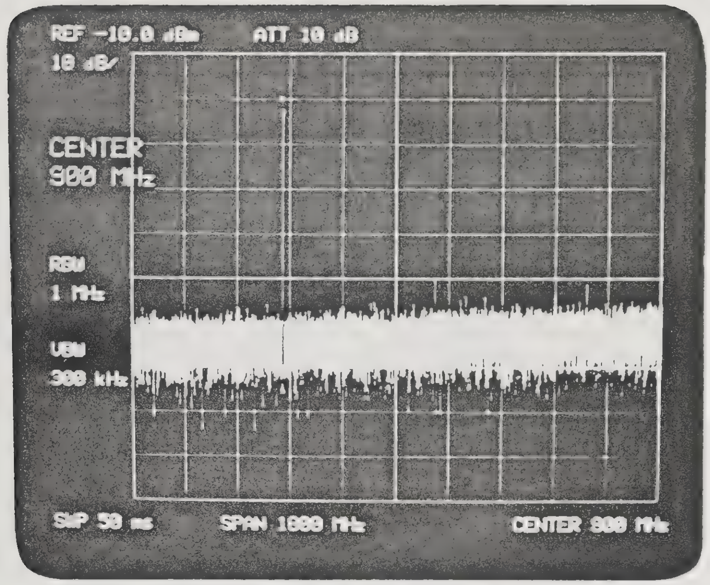


Fig. 3-1 Initial function setting upon power on or reset

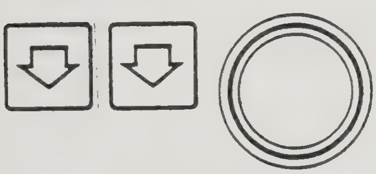
To change function settings, first press the pertinent function key and then adjust the Data knob until the desired setting is obtained. The Data step switches   or Data number/units keyboard (Data keyboard)  may be used instead of the Data knob.

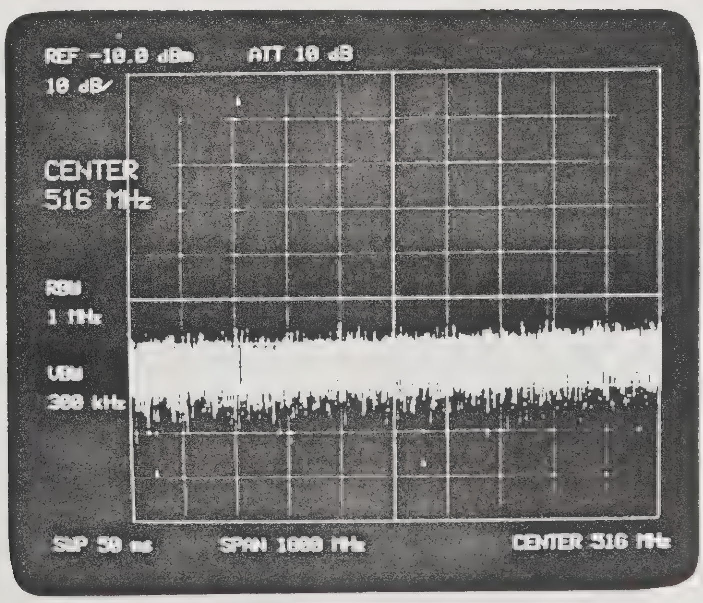
For example, to move the object signal to the center of the display, first press 

to activate the center frequency. The activated function is displayed to the left of the screen with enlarged readout. Since the center frequency readout is always provided at the bottom right corner of the display, there are now two identical center frequency readouts on the screen. The center frequency remains active until another function key is operated.

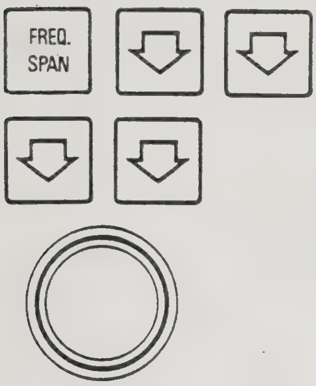


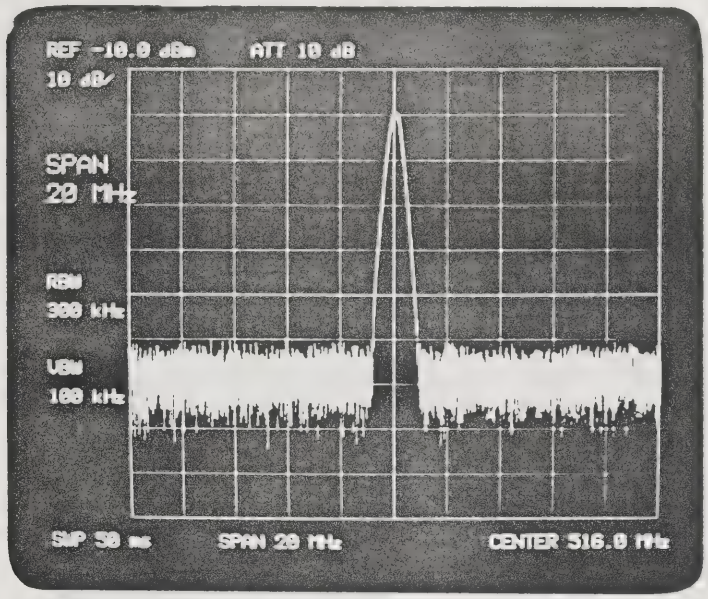
Use the Data knob to position the signal to the center of the display. For quicker control, first use the Data step keys to bring the signal to the near center, then make fine tuning with the Data knob. This practice may also be used for quick positioning of the marker (to be described later). The center frequency of the signal can now be read out.



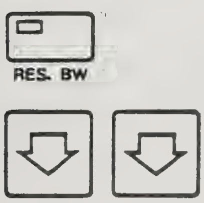


For better frequency resolution narrow the frequency span (frequency span from the left to right end of the display) with the FREQ. SPAN key and DATA control.

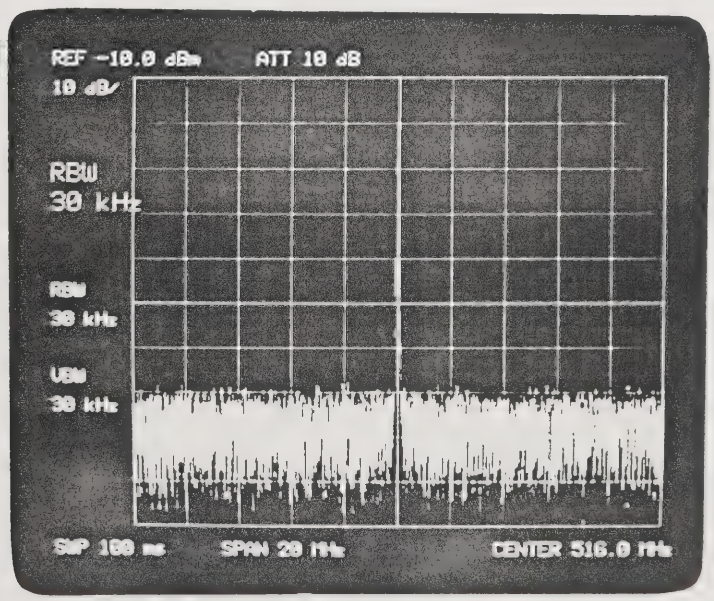




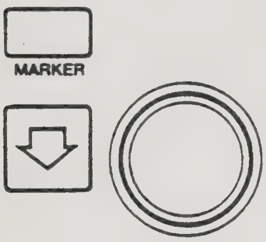
For higher signal resolution, the analyzer's IF bandwidth can be narrowed using the RES. BW. key and Data step key (down). Since the sweep time is normally set to AUTO, narrowed bandwidth causes lower sweep rate.

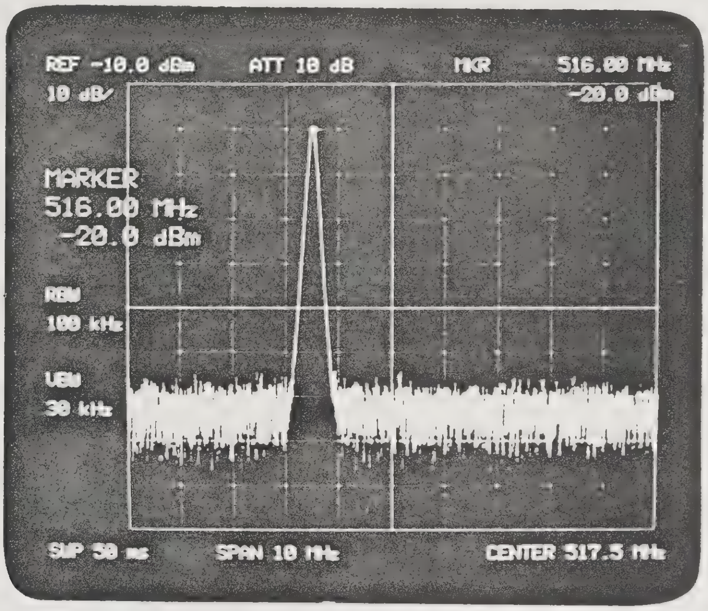


or



The signal frequency and level can be read out by using a marker (bright spot) without bringing the signal to the center of the display.
The MARKER key activates a single marker. The marker will move on the trace with the rotation of the Data knob. Tune the marker with the Data knob to position it to the signal peak. The signal's amplitude and frequency is read out directly. While the marker is on the display the amplitude and frequency at the marker are always read at the top right corner of the display.





The simplified operating procedures hitherto described are intended to help you understand the following basic operating routine for the analyzer:

(1) Press the desired function key.

(2) The activated function data is read out in enlarged characters.

(3) Change the function setting or move the marker with the DATA controls.

3-3. PANEL DESCRIPTION

3-3-1. Front Panel Description (See Figure 3-2.)

(1) POWER push switch

(2) STANDBY/ON indicator lamps

The STANDBY lamp comes on when the instrument is plugged into an electrical outlet with the POWER switch set at the STANDBY (out) position. The ON lamp comes on when the POWER switch is pressed into the ON position.

(3) MASTER RESET key

Resets the entire circuits of the analyzer into the condition shown on page 4-2.

(4) LCL (Local) key

Returns the analyzer from remote operation mode (by an external GP-IB controller) into local operation mode (by front panel keys of the instrument).

(5) RMT (Remote) indicator lamp

Goes on when the analyzer is in remote operation mode.

(6) T.G. (Tracking Generator) key

Activates the output of the integrated tracking generator.

(7) T.G. LEVEL key

Controls attenuation level for the tracking generator between 0 dB and 50 dB at 10 dB steps.

(8) TRACKING GENERATOR OUTPUT (50 Ω) connector

The output frequency range is from 400 kHz to 1800 MHz with an output impedance of 50 Ω.

(9) T.G. FREQ. ADJ. control

Corrects tracking error.

(10) GROUP DELAY key

Activates group delay measurement.

(11) PHASE key

Activates phase measurement.

(12) NORMAL key

Returns the instrument to the normal spectrum analyzer mode.

(13) INPUT-2 key

Selects INPUT-2: 10 MHz to 1000 MHz, max. -30 dBm, ±20 Vdc.
Operatable only when the optional preamplifier is built in.

(14) INPUT-2 connector

INPUT connector for the optional preamplifier.

(15) INPUT-1 DC key

Selects DC coupled INPUT-1: 50 Hz to 1800 MHz, max. +20 dBm, 0 Vdc

(16) INPUT-1 AC key

Selects AC coupled INPUT-1: 10 kHz to 1800 MHz, max. +20 dBm, ±25 Vdc

(17) CAL. screwdriver control

Used to adjust the calibration signal level (at INPUT-1) to -20 dBm.

(18) INPUT-1 connector

(19) INPUT ATT. key

Controls input attenuation level from 0 dB to 50 dB at 10 dB steps.

(20) AUTO key

Automatically sets input attenuation level from 10 dB to 50 dB at 10 dB steps.

(21) PROBE POWER connector

Four-pin connector to supply a power of ±15 V to an active probe.

(22) CAL. OUT. connector

Outputs a calibration signal of 50 MHz, -20 dBm ±0.3 dB.

(23) DATA knob

Continuously controls measurement function or marker position.

(24), (25) DATA step keys

Steps measurement function or marker position up or down.

(26) HOLD key

Inhibits function setting updating or entry from the DATA knob, DATA step keys, or data keyboard. Operation of any one of the FUNCTION keys clears the HOLD state.

(27) ENABLE indicator lamp

Goes on when data updating or entry is enabled. Goes off when the HOLD key is pressed.

(28) SWEEP TIME key

Sets sweep time between 20 ms and 1000 sec.

(29) AUTO (SWEEP TIME) switch

Automatically sets sweep time according to frequency span or RES. BW setting, etc.

(30) RES. BW (Resolution Bandwidth) key

Sets IF bandwidth between 10 Hz and 1 MHz at 1 to 3 sequence.

(31) AUTO (RES. BW) key

Automatically sets IF bandwidth according to frequency span.

(32) VIDEO BW key

Sets video filter's pass bandwidth between 1 Hz to 1 MHz at 1-3 sequence.

(33) AUTO (VIDEO BW) key

Automatically sets video bandwidth according to frequency span.

(34) CF STEP SIZE (Center Frequency Step Size) key

Determines center frequency stepping span by the DATA step keys.

(35) AUTO (CF STEP SIZE) key

Automatically sets the CF STEP SIZE to 1/10 of the frequency span.

(36) CENT. FREQ. (Center Frequency) key

Sets center frequency between 0 Hz and 1800 MHz.

(37) FREQ. SPAN (Frequency Span) key

Sets frequency span between 100 Hz and 2000 NHz.

(38) REF. LEVEL (Reference Level) key

Sets the reference level between -90 dBm and +50 dBm.

(39) DATA number/units keyboard

Used to enter measurement data or marker frequency directly with numerical data and units.

(40) BACK SPACE key

Backspaces data entry steps to permit correction of entry error.

(41) MHz dB sec/PHASE OFFSET key

One of the three unit keys. Data entry is completed by pressing a unit key after numerical data is keyed-in from the DATA keyboard. When phase measurement is active, pressing this key enables phase offset data entry.

(42) kHz +dBm msec/G.D. OFFSET key

One of the three unit keys. When the group delay function is active, pressing this key enables group delay offset data entry. Positive reference level data can be input with this key

after the reference level data is keyed-in from the DATA keyboard.

(43) Hz -dBm sec key

One of the three unit keys. To enter negative reference level data, first key-in the positive level data from the DATA keyboard, then press this key.

(44) INTENSITY control

Controls intensity of all CRT writing.

(45) FOCUS

A screwdriver adjustment which focuses all CRT writing.

(46) TRACE ALIGN

A screwdriver adjustment which tilts all displayed CRT information.

(47) SWEEP IND. (Sweep Indicator) lamp

Goes on during sweep.

(48) INT. (Internal) key

Automatically repeats internally-triggered sweep.

(49) LINE key

Triggers sweep start synchronously with the line frequency.

(50) EXT. (External) key

Triggers sweep start by an external trigger signal (TTL level) applied to the rear EXT. TRIG connector. Trigger occurs at HIGH to LOW transition of the external trigger signal.

(51) VIDEO key

Triggers sweep start if a detected IF signal reaches to a level set by the TRIG. LEVEL control (52).

(52) TRIG. LEVEL (Trigger Level) control

Controls trigger level for a detected video signal. If sweep fails to start when the VIDEO key is pressed, adjust this control for the adequate trigger level.

(53) SINGLE key

Each depression of this key triggers a single sweep.

Note: More detailed operations of the TRACE keys (54) to (63) will be described in paragraph 4-10.

(54) WRITE A key

Updates and displays trace memory A for each sweep.

(55) WRITE B key

Updates and displays trace memory B for each sweep.

(56) VIEW A key

Stops updating trace memory A and displays the latest signal response.

(57) VIEW B key

Stops updating trace memory B and displays the latest signal response.

(58) A ⇄ B key

Exchanges the contents of trace memories A and B.

(59) B-DL → B key

Display line level is subtracted from trace memory B contents and the result is written into trace memory B.

(60) A-B → A key

Trace B is subtracted from trace A for each sweep and the result is written into trace memory A.

(61) B → B' key

Writes trace memory B contents to trace memory B'.

(62) VIEW A' key

Displays the contents of trace memory A'

(63) VIEW B' key

Displays the contents of trace memory B'.

Note: More detailed operations of th MARKER keys (64) to (73) will be described in paragraph 4-9.

(64) MARKER key

Activates a single marker.

(65) MKR OFF key

Erases all markers from the display.

(66) Δ (delta) key

Activates two markers and provides a readout of frequency difference and level difference between the two markers.

(67) PEAK SEARCH key

Positions the marker to the highest signal peak.

(68) ZOOM key

Zooms in on a signal specified by a marker. Press the ZOOM key, identify the signal to be zoomed in on with the marker, then operate the Data step key (down) to narrow the frequency span.

(69) MKR → CF key

Substitutes the center frequency with a marker frequency to position the marker to the center of the display.

(70) SIGNAL TRACK key

Positions a drifting signal always at the center of the display.

(71) MKR/Δ → STEP SIZE key

Substitutes the center frequency step size with a marker frequency. In the Delta (Δ) mode the center frequency step size is given by the frequency difference between two markers.

(72) FREQ. CNTR key

Directly counts input signal frequency.

(73) MKR → REF. key

Substitutes the reference level with a marker level to position the marker on the top graticule of the display.

Note: More detailed operations of the DISPLAY LINE key (74) will be described in paragraph 4-12.

(74) DISPLAY LINE key

Activates a display line (horizontal cursor line).

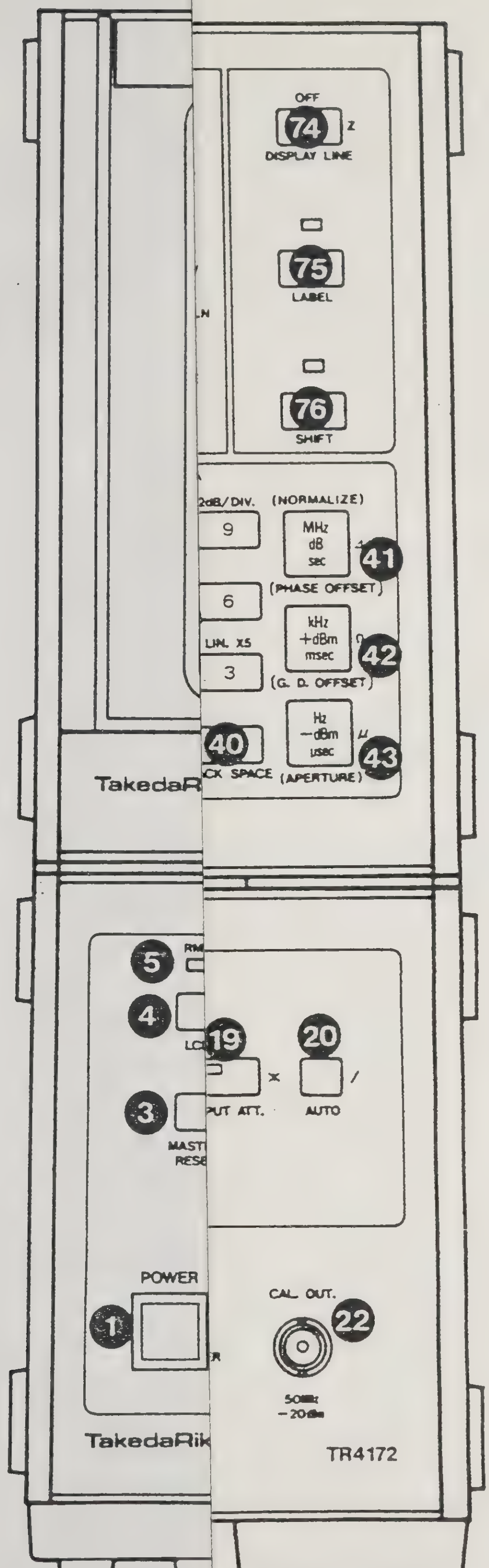
(75) LABEL key

Permits entry of any alphanumeric characters in the top display area of the CRT screen. The entry procedure will be described in paragraph 4-12.

(76) SHIFT key

When pressed a first time, the analyzer enters the Shift Key mode and the functions indicated just above each key in yellow letters are made available. The Shift Key mode is cleared when any of the keys is pressed or the SHIFT key is pressed a second time.

Each key function in the Shift Key mode will be described in Section 4.


OFF
DISPLAY LINE
LABEL
SHIFT
2dB/DIV.
(NORMALIZE)
MHz
dB
sec
(PHASE OFFSET)
kHz
+dBm
msec
LIN. X5
(G. D. OFFSET)
Hz
−dBm
μsec
(APERTURE)
TakedaRi
AUTO
POWER
CAL. OUT.
TakedaRik
TR4172

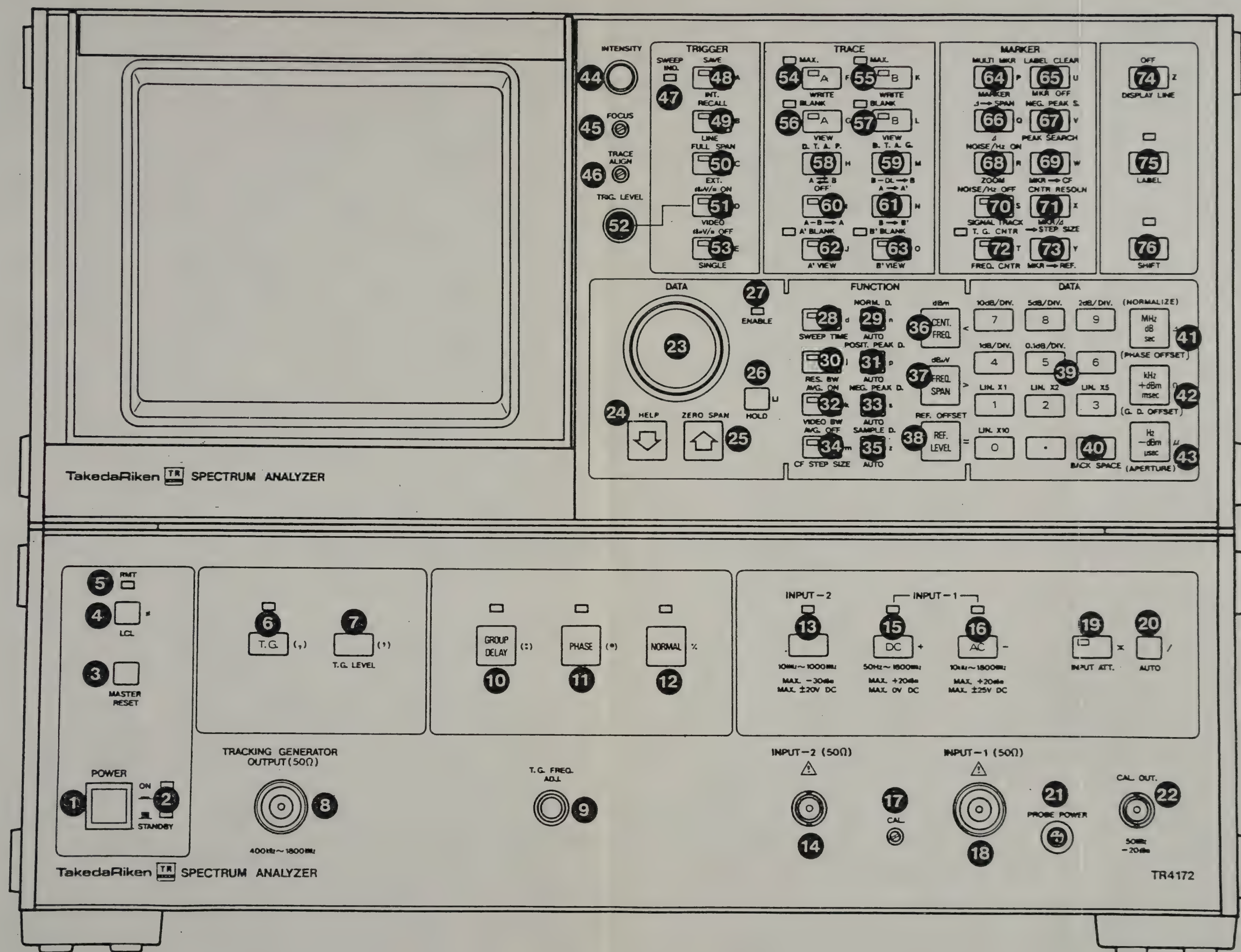


Fig. 3-2 Front panel

3-3-2. Rear Panel Description (See Figure 3-3.)

(1) J3 IF INPUT
Accepts signal from RF section J3 IF OUTPUT (11) via the supplied cable.

(2) J1 BUS connector
Connects to the RF section J1 BUS connector (10) via the supplied cable.

(3) Ground terminal
When a two-conductor plug adapter is used for power connection, the ground lead of the adapter or this ground terminal should be connected to the earth ground.

(4) ADDRESS switch array
Used to designate the device address (1 to 5) of the instrument for remote operation.

(5) GP-IB connector
Accepts a GP-IB cable from an external controller or X-Y plotter.

(6) EXT. TRIG input
Accepts an external trigger signal. When the front TRIGGER function is set to EXT. mode, the analyzer is triggered by the negative leading edge of an external TTL trigger signal.

(7) XYZ outputs
Optional X, Y, and Z axis outputs.

(8) J2 connector
Connects to the RF section J2 connector (15) via the supplied cable.

(9) AC LINE input
Accepts a power cable.

(10) J1 BUS connector
Connects to the display section J1 BUS connector (2) via the supplied cable.

(11) J3 IF OUTPUT
Connects to the display section J3 IF INPUT connector (3) via the supplied cable.

(12) J4 INT. STD OUTPUT

A 10 MHz internal master oscillator output (TTL compatible). This output should be adjusted to exactly 10 MHz with screwdriver adjustment STD ADJ. (13). (See page 4 - 89)

(13) STD ADJ.

A screwdriver adjustment which adjusts the output frequency of J4 INT. STD OUTPUT connector (12) to exactly 10 MHz.

(14) Ground terminal

(15) J2 connetor

Connects to the display section J2 connector (8) with the supplied cable.

(16) AC LINE connector

Accepts a power cable.

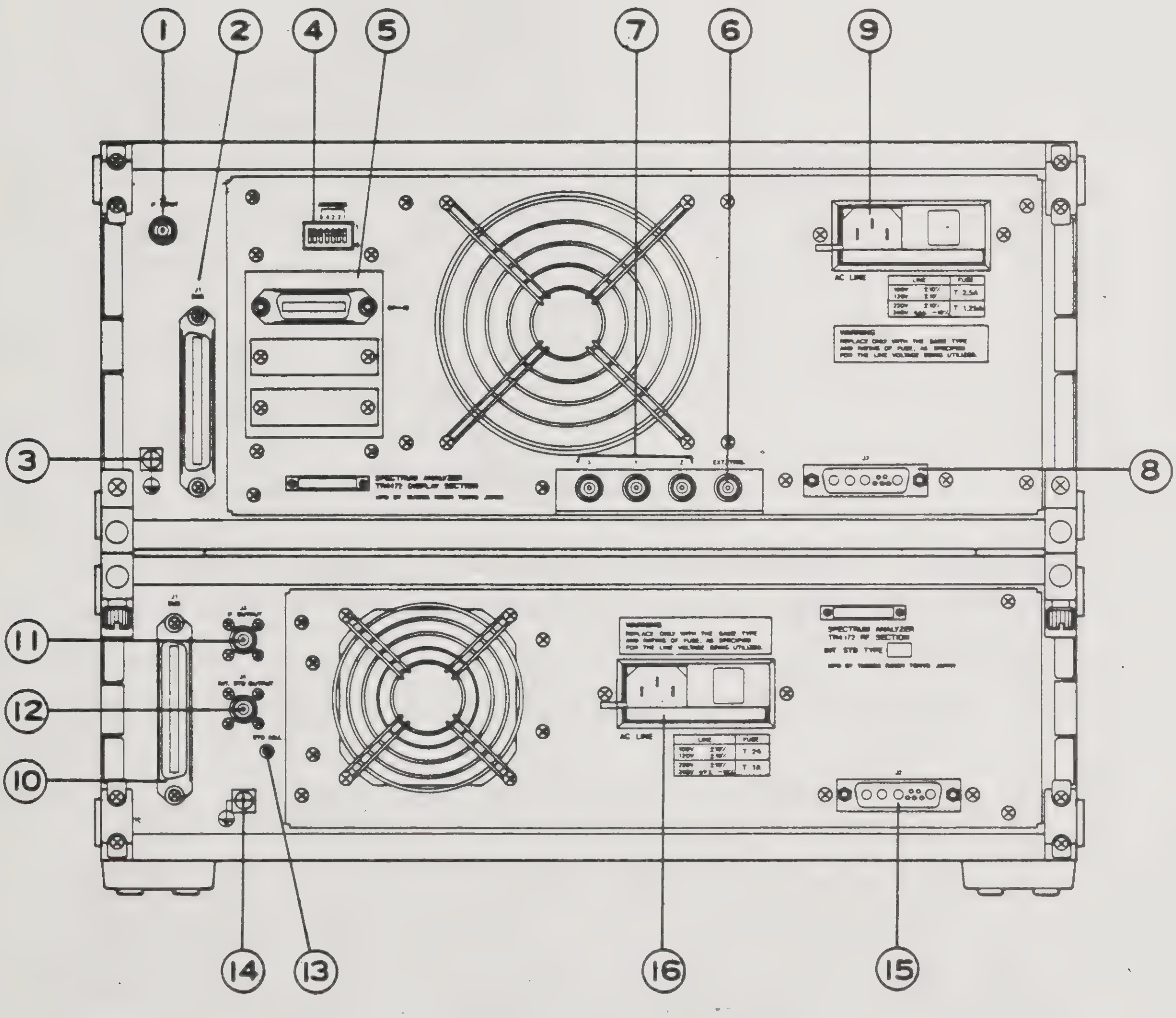


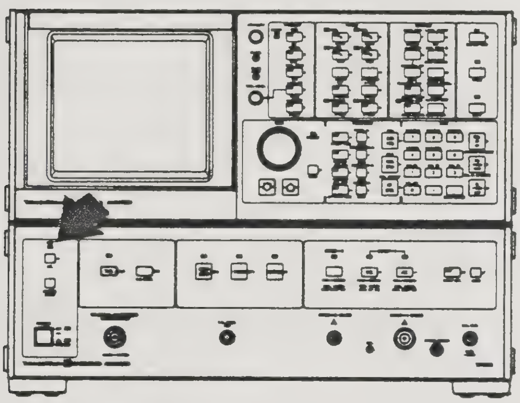
Fig. 3-3 Rear panel

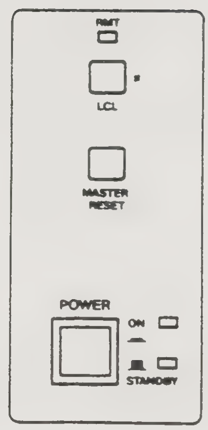
SECTION 4
OPERATION

4-1. INTRODUCTION

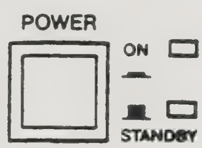
This section describes the versatile measuring functions of the TR4172 Spectrum Analyzer in more detail.

4-2. POWER, MASTER RESET, AND LCL KEYS





4-2-1. POWER Switch



Make signal and power connections for the instrument as indicated in Figure 2-2. When a two-conductor plug adapter is used for the power connection, be sure to connect the ground lead of the adapter of the rear ground terminal of the instrument to the earth ground.

Table 4-1 POWER switch setting

Power cables unplugged	Instrument completely turned off
Power cables plugged in STANDBY	Master crystal oscillator and back-up battery are turned on.
ON	Instrument completely turned on

When the instrument is plugged into electrical outlets, the STANDBY indicator lamp lights to indicate that the internal master crystal oscillator, and back-up Ni-Cd battery are turned on. When the POWER push switch is pressed into the ON position, the ON indicator lamp lights to indicate that the instrument is completely turned on.
To use the analyzer within its accuracy specifications, approximately 24 hours of warm-up time is required under the STANDBY or ON state.
The internal memory contents remain intact for approximately two weeks even if the instrument is unplugged from its supply outlets, provided the back-up battery is fully charged beforehand. The Ni-Cd battery will require a charging time of two to three days.
Unless the instrument is to be left unused for a prolonged period of time, it is recommended that the analyzer be left in the STANDBY state with its power cables plugged into their supply outlets.

4-2-2. MASTER RESET

When pressed, the MASTER RESET key clears the analyzer's functions to the initial state. The functions affected by the MASTER RESET key and their initial states are listed below.
The MASTER RESET key may be used if the analyzer is malfunctioning due to noise interference or other causes.

<u>Initial States of Functions Affected by the MASTER RESET</u>

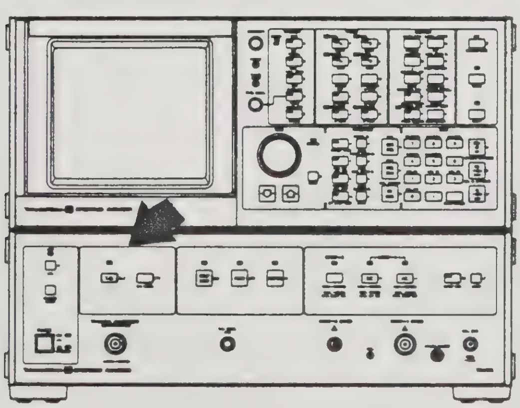
CENT. FREQ.	900 MHz
FREQ. SPAN	1800 MHz
Reference level	-10 dBm
SWEEP TIME	AUTO (50ms)
RES. BW	AUTO (1 MHz)
VIDEO BW	AUTO (300 kHz)
CF STEP SIZE	AUTO
INPUT ATT.	AUTO (10 dB)
INPUT MODE	AC
NORMAL	ON
PHASE	OFF
GROUP DELAY	OFF
T. G.	OFF
TRIGGER	INT.

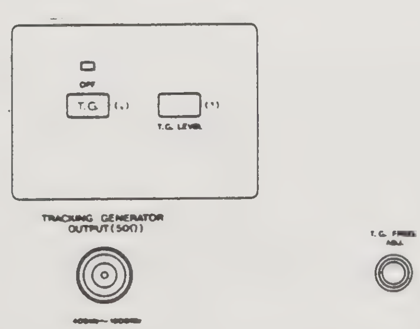
TRACE	WRITE A
	BLANK A'
	BLANK B
	BLANK B'
	Other keys OFF
MARKER	All OFF
DISPLAY LINE	OFF
LABEL	OFF
SHIFT	OFF
INT. STD OUT	OFF
dB/DIV.	10 dB/DIV.

4-2-3. LCL

The LCL (Local) key is operative when the analyzer is in remote operation mode.
When the analyzer is remotely controlled by an external GP-IB controller, the RMT indicator lamp just above the LCL key lights to indicate that front panel control of the analyzer is prevented except for the MASTER RESET key operation.
When the LCL key is pressed, the RMT lamp will go off to indicate that front panel control of the analyzer is enabled. If the Local Lockout command is sent from the GP-IB controller, however, the LCL key remains inoperative.

4-3. T.G., T.G. LEVEL, AND T.G. FREQ. ADJ.





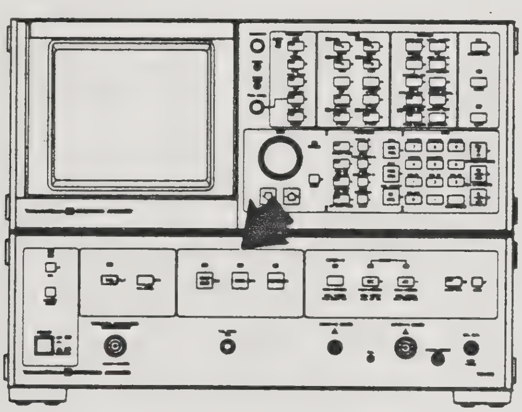
These keys are for internal tracking generator control. Press [T.G] to activate the tracking generator; the indicator lamp just above the TG key lights.

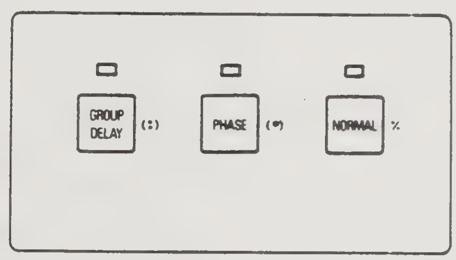
Press [SHIFT] [T.G] (OFF) to deactivate the tracking generator; the indicator lamp goes off.

The tracking generator is used for phase or group-delay measurements as well. More detailed operations of the tracking generator, including the T.G. LEVEL and T.G. FREQ. ADJ. controls, will be described in SECTION 5. For normal operations of the analyzer, leave the tracking generator inactive. This will enable measurement capability at the maximum sensitivity of the instrument. When the tracking generator is activated, the analyzer's sensitivity may be degraded due to noise interference from the tracking generator.

The tracking generator is also activated when the PHASE or GROUP DELAY key is pressed. If the normal measurement mode (for spectrum analysis) is restored with the NORMAL key, the tracking generator will remain active. To deactivate the tracking generator press SHIFT, T.G..

4-4. GROUP DELAY, PHASE, AND NORMAL KEYS





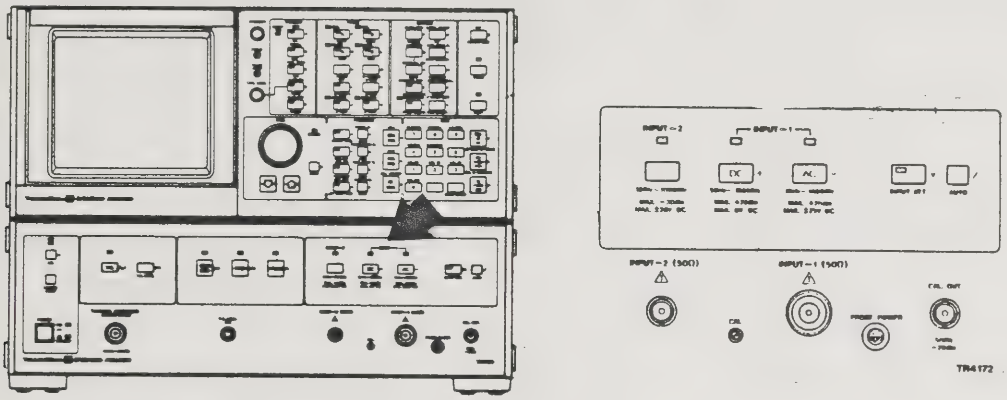
These keys select analyzer's mutually exclusive measurement modes. When one of [GROUP DELAY], [PHASE], and [NORMAL] is pressed the corresponding measurement mode is selected and the indicator lamp for the selected mode lights.

For details of phase measurement and group delay measurement see Section 6 and 7 respectively.

The analyzer should normally be placed in the Normal mode by pressing the NORMAL key.

Once the GROUP DELAY or PHASE measurement mode is entered by pressing the respective key, the internal tracking generator is activated and remains activated even after the analyzer is returned to the NORMAL measurement mode. When the tracking generator is unused, press SHIFT, T.G. to deactivate it.

4-5. INPUT



These keys are input controls and settings of RF attenuator.

4-5-1. INPUT-2

INPUT-2 is dedicated for the optional preamplifier. To select the preamplifier input press the INPUT-2 key; the indicator lamp just above the key will light to indicate that INPUT-2 is selected. When the preamplifier is not built-in, the lamp remains off even if pressed. The specifications for INPUT-2 are:

Frequency range: 10 MHz to 1000 MHz

Input impedance: 50 Ω

Maximum input level: -30 dBm, $\pm$20 Vdc

4-5-2. INPUT-1 (DC, AC)

To select INPUT-1 press DC or AC.

When DC is pressed INPUT-1 is DC coupled to the 1st mixer to enable signal response observation over a frequency range from 50 Hz to 1800 MHz.

Never apply a DC voltage to INPUT-1 when DC mode is selected; otherwise the input circuit of th 1st mixer will be permanently damaged.

When [AC] is pressed INPUT-1 is AC coupled to the 1st mixer to permit signal response observation over a frequency range from 10 kHz to 1800 MHz. The maximum allowable input level is +20 dBm or ±25 Vdc. When the analyzer is turned on or the MASTER RESET key is pressed, the AC mode for INPUT-1 is automatically selected.

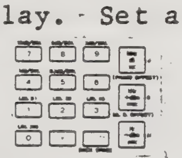
4-5-3. INPUT ATT. [INPUT ATT.] [AUTO]

The INPUT ATT. key controls the input attenuator's attenuation level between 0 dB and 50 dB at 10 dB steps.

Normally, the input attenuator is controlled in the AUTO mode, in which the attenuation level is automatically set between 10 dB and 50 dB according to the REF. LEVEL key setting. To protect the input mixer, 0 dB attenuation is not selected when in the AUTO mode.

The currently selected attenuation level is always read at the top of the CRT display such as ATT XXdB.

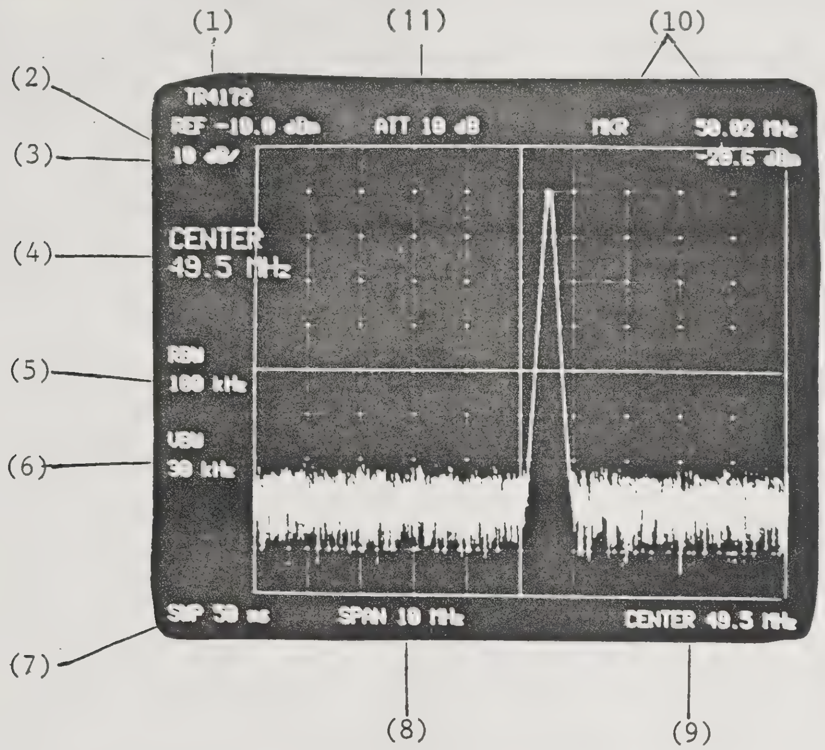
When manual setting of the input attenuator is desired, press [INPUT ATT.]; the key indicator lamp will come on.

The attenuation level is now active and the current attenuation level "ATT XXdB" is read to the active function display area of th CRT display. Set attenuation to the desired level with  or [⇩] [⇧] or  the DATA keyboard.

To return the attenuator to the AUTO control mode press [AUTO]. The key indicator lamp on [INPUT ATT.] will go off and the attenuator is automatically controlled according to the REF. LEVEL setting.

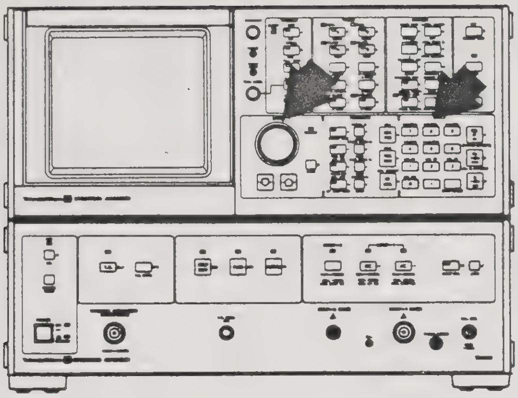
4-6. CRT DISPLAY

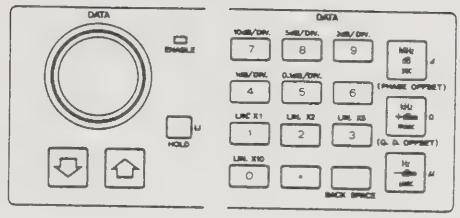
The CRT display presents the signal response trace, graticule, measurement data, and labels.



(1)	TR4172	Label which can be optionally written by the user (P. 4-47)
(2)	REF	Reference level (P. 4-13)
(3)	10 dB/	Vertical scale per division (P. 4-14)
(4)	(CENTER)	Active function (P. 4-10)
(5)	RBW	Resolution bandwidth (P. 4-16)
(6)	VBW	Video bandwidth (P. 4-16)
(7)	SWP	Sweep time (P. 4-15)
(8)	SPAN	Frequency span (P. 4-11)
(9)	CENTER	Center frequency (P. 4-10)
(10)	MKR	Marker (P. 4-17)
(11)	ATT	Input attenuator level (P. 4-6)

4-7. DATA

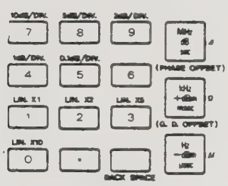




Any function can be selected by pressing the appropriate front panel function key, and changed by using any or all of the following DATA controls:

: DATA knob

: DATA step keys



: DATA number/units keyboard (DATA keyboard)

4-7-1. DATA Knob

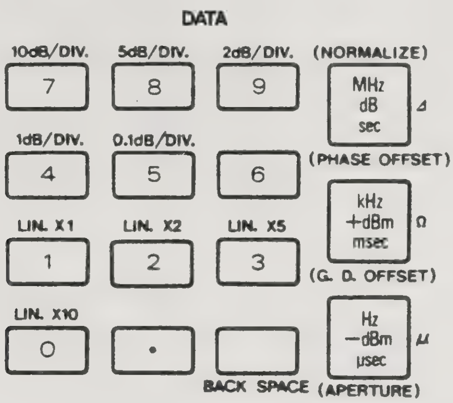
Continuously turning the DATA knob clockwise increases function data which is currently active. In the MARKER mode clockwise rotation of the DATA knob moves the marker to the right. In the DISPLAY LINE mode it moves the display line upwards. Turning the DATA knob counterclockwise decreases function data.

4-7-2. DATA Step Keys

The DATA step keys change function data in predetermined steps each time they are pressed. In the MARKER mode each operation of the step keys moves a marker one division on the horizontal axis of the CRT display.

Step size can be changed by using the MKR/Δ →STEP SIZE or CF STEP SIZE key. More detailed operations of these keys will be described in the sections pertaining to FUNCTION and MARKER.

4-7-3. DATA Keyboard



The DATA keyboard permits direct entry of numerical data. Function data can be entered by pressing a unit key after operating data number keys. If you have missed entry of number data, press the BACK SPACE key and then retry correct data entry.

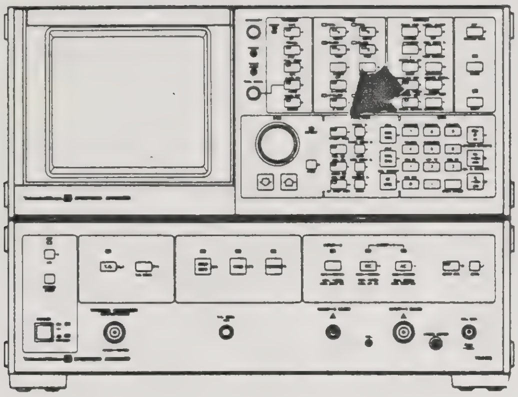
4-7-4. HOLD

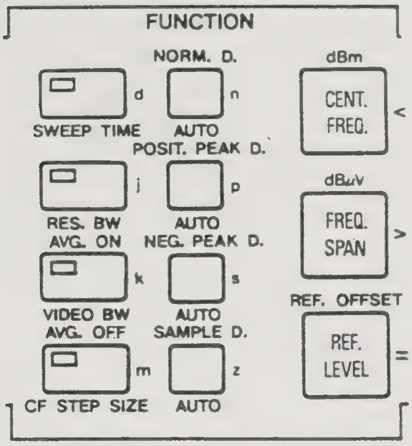
ENABLE

HOLD

Data change or entry using the DATA knob, DATA step keys or DATA keyboard is inhibited by pressing the HOLD key. (The ENABLE indicator lamp just above the HOLD key goes off.)
The HOLD state is cleared by operating a key other than the DATA controls or keys; the ENABLE indicator lamp goes on to indicate that data change or entry is enabled.

4-8. FUNCTION





When the analyzer is initially switched on, center frequency, frequency span, reference level, etc. are automatically set to the initial values shown on page 4-2. These values can be changed by using the FUNCTION keys and DATA controls.

Sweep time, manual setting of bandwidth (normally automatically set), or vertical scale can also be controlled with the FUNCTION keys and DATA controls. To specify function data first press the appropriate function key.

The activated function is shown on the left side of the CRT display.

The data can be changed with the DATA knob, DATA step keys or DATA keyboard. The function remains active until another FUNCTION key or the MARKER key is operated.

The functions of the individual FUNCTION keys are described below.

4-8-1. CENT. FREQ.

This key is used to activate center frequency, which can be set over a range from 0 Hz to 1800 MHz. The maximum number of digits (resolution) of center frequency setting depends on the selected frequency span.

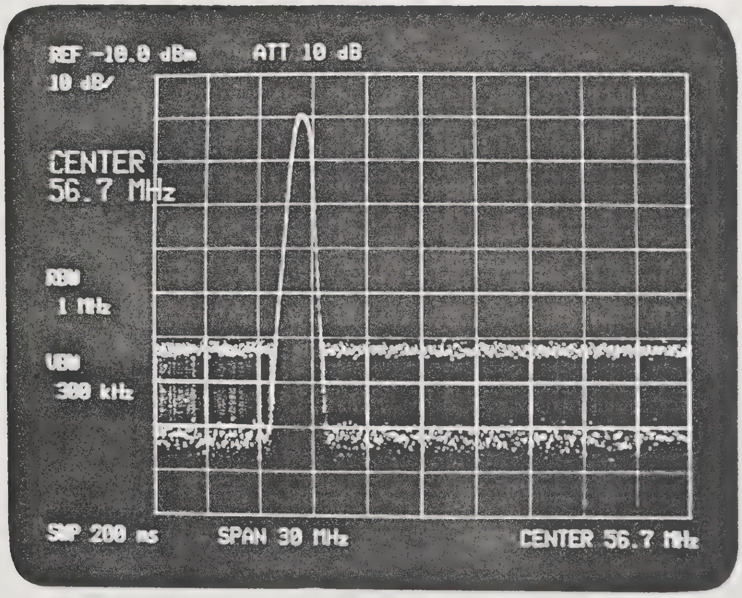
The DATA knob allows fine control of center frequency. The DATA step keys enables frequency shift in steps (normally 1/10 of the selected frequency span). The DATA keyboard enables direct entry of numerical center-frequency data. Using the DATA keyboard, the actual data entry occurs when one of the units keys, MHz, kHz or Hz, is pressed after numerical data is entered.

Center frequency is always shown at the bottom right corner of the display (except in Log Display mode).

4-8-2. FREQ. SPAN [FREQ. SPAN]

This key is used to activate the frequency span.
Frequency apan across the axis can be set over a range from 100 Hz to 2000 MHz; that across one division of the graticule is 1/10 of the frequency span.
The frequency span can be changed with the DATA knob or DATA step keysand DATA keyboard. The DATA keyboard enables direct entry of numerical frequency-span data.
The display always presents frequency span data at the bottom of the screen (except in Log. Display mode). When the RBW and VBW functions are set in AUTO mode, resolution bandwidth and video bandwidth are automatically set to the optimum according to the selected frequency span.

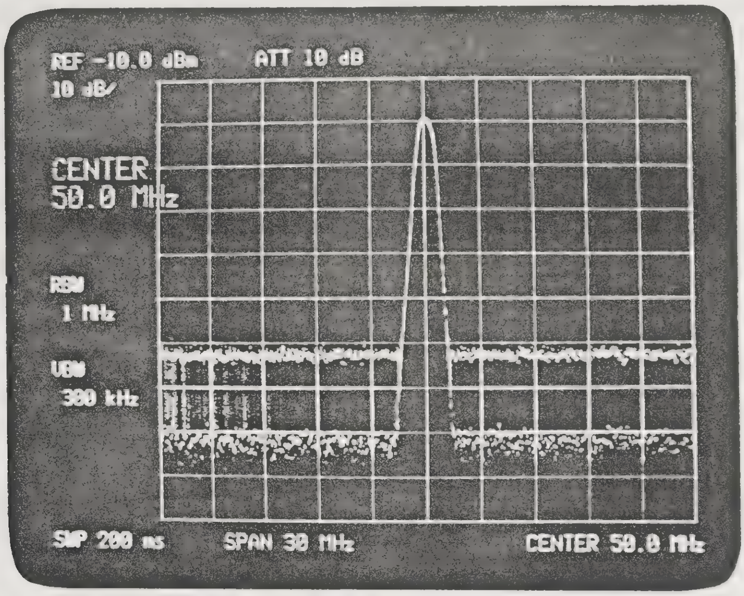
Example of [CENT. FREQ.] and [FREQ. SPAN] usage:



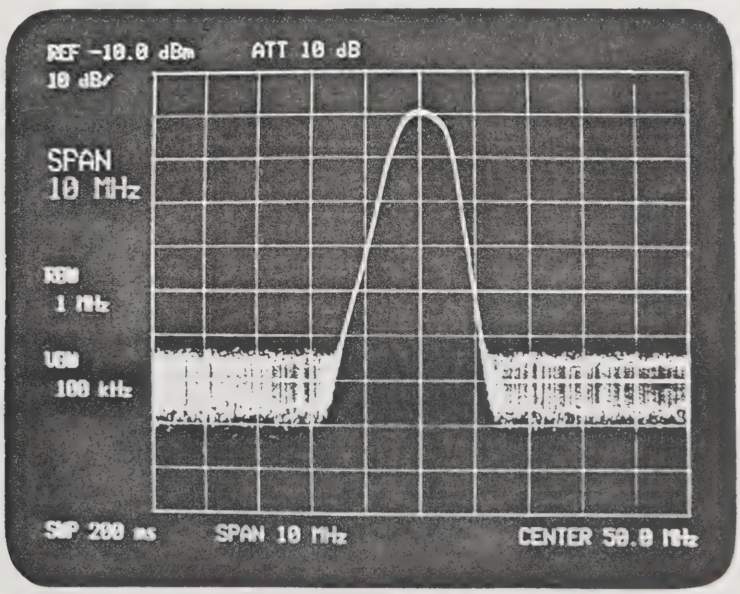
The signal to be measured is to the left of center of the display. Reduce the center frequency with 

to shift the signal to the right.

Then tune the signal to the exact center of the display with  .



For better frequency resolution narrow the frequency span with



If the signal deviates from the center of the CRT when the frequency span is narrowed, reposition the signal to the center with the CENT. FREQ. key and DATA knob.

Zero Frequency Span:

When [SHIFT] [ZERO SPAN ⇧] are pressed, the horizontal display axis becomes calibrated in time and the spectrum analyzer is fixed tuned to the center frequency. As a result, the analyzer operates as a receiver fixed tuned to the center frequency.

Press [SHIFT] [ZERO SPAN ⇧] again to restore the normal spectrum analyzer function with the horizontal display axis calibrated for frequency.

4-8-3. REF. LEVEL [REF. LEVEL]

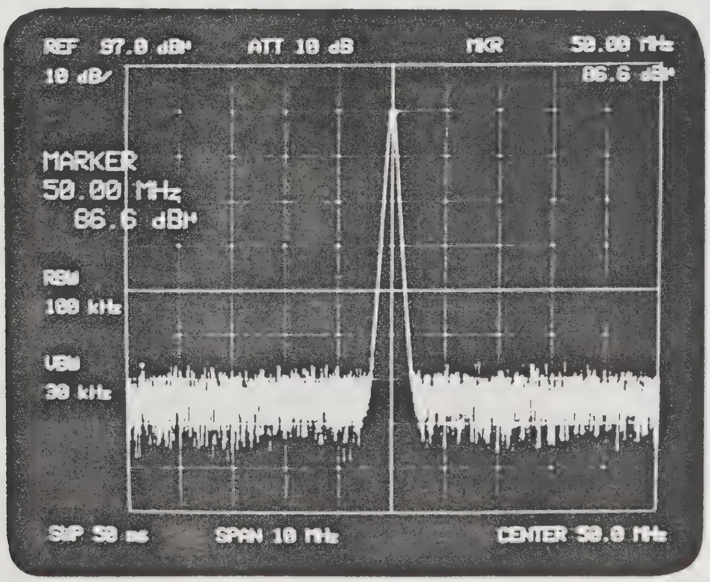
This key is used to activate the reference level at the top graticule of the CRT display. The reference level can be specified over a range from -90 dBm to +50 dBm in 0.1 dB steps. The DATA step keys control the reference level in 10 dB steps, while the DATA knob can control it in 0.1 dB steps.

The DATA keyboard enables direct entry of reference level values. For entry of a positive value press [kHz +dBm msec], and for entry of a negative value press [Hz −dBm μsec] after keying in the numerical data.

The specifiable range of the reference level may be reduced to smaller than -90 dBm to +50 dBm depending on the input attenuator setting. Reference level can be specified in dBμ with [SHIFT] [dBμV FREQ. SPAN].

Pressing [SHIFT] [dBm CENT. FREQ.] returns the reference level readout to dBm.

[SHIFT] [dBm CENT. FREQ.]



4-8-4. Vertical Scale Control

The scaling of the vertical graticule divisions of the CRT display is normally set in 10 dB/div.

Look at the top left corner of the display in the following figure. "REF -20.7 dBm" shows that the reference level is presently read in dBm, and "10 dB/" indicates that the scaling of the vertical graticule division is 10 dB/div. A unit of dBμ is also selectable (see paragraph 4-8-3). Scaling can also be selected from 5, 2, 1, and 0.1 dB per division, and linear scaling.

For 5 dB/div. press [SHIFT] [8 (5dB/DIV.)].

For 2 dB/div. press [SHIFT] [9 (2dB/DIV.)].

For 1 dB/div. press [SHIFT] [4 (1dB/DIV.)].

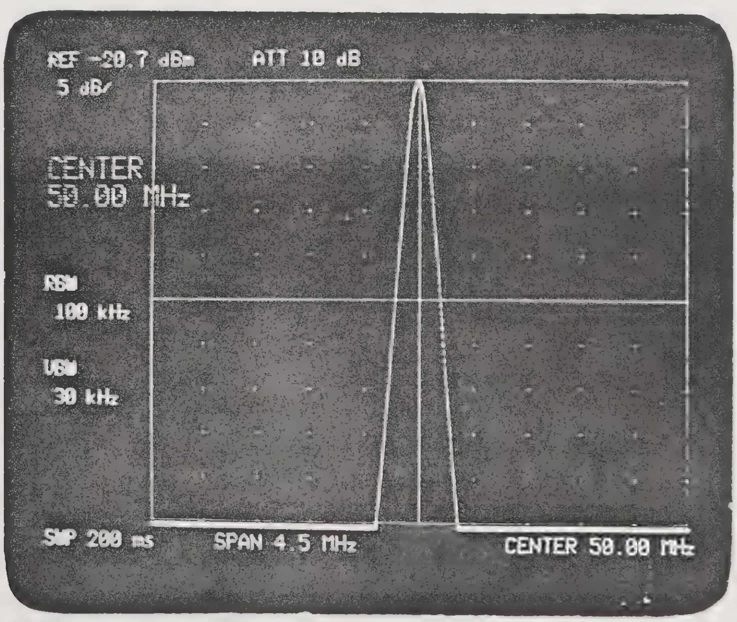
For 0.1 dB/div. press [SHIFT] [5 (0.1dB/DIV.)].

For 0.5 dB/div. press [SHIFT] [5] [1].

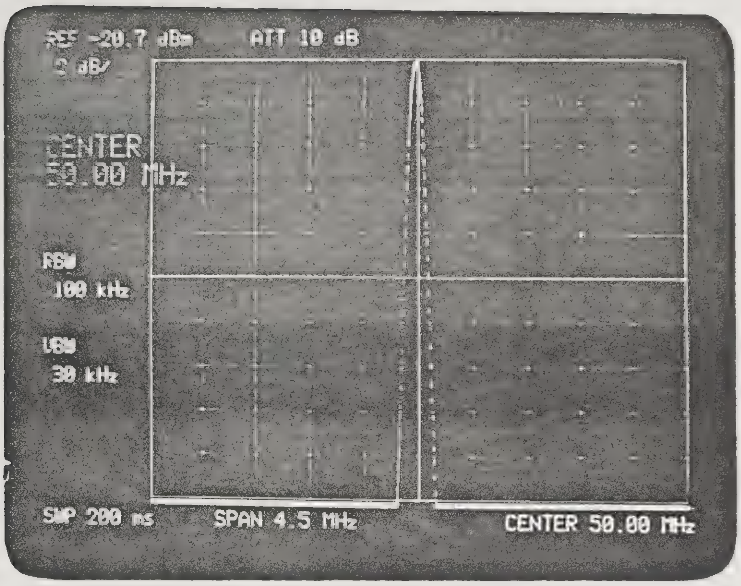
For 0.2 dB/div. press [SHIFT] [5] [2].

In the 0.1 dB/div., 0.2 dB/div., 0.5 dB/div., the effective range of the vertical scale is down to 8 divisions below the reference level, with display linearity not guaranteed in the bottom two divisions.

[SHIFT] [8 (5dB/DIV.)]



2dB/DIV.
SHIFT 9



The scale can be set up for linear units to read amplitudes proportional to input signal power.

If SHIFT, 1 (LIN. X1) are pressed linear scale x1 is selected, with the top and bottom graticules assigned to the reference and 0 V levels, respectively.

The scale can be changed in allowable increments of x2, x5, and x10 with SHIFT 2 (LIN. X2), SHIFT 3 (LIN. X5), and SHIFT 0 (LIN. X10), respectively. In this case the reference level does not change.

4-8-5. SWEEP TIME

SWEEP TIME AUTO

This key is used to activate sweep time within a range from 20 ms to 1000 sec. When the analyzer is initially switched on, sweep time control is set in AUTO mode, in which it is automatically set according to frequency span, resolution bandwidth or video bandwidth to minimize level error.

SWEEP TIME clears the AUTO mode to permit manual setting of sweep time (indicator on the key goes on) with the DATA knob, DATA step keys, or DATA keyboard.

AUTO again selects the AUTO mode for sweep time control; the indicator on the SWEEP TIME key goes off.

If sweep time is set too long in the AUTO mode, it can be temporarily reduced with [SWEEP TIME] [↓] [↓] [↓] for quick observation of signal response. In this case, if the error of level reading exceeds 0.5 dB, message "UNCAL" will be shown.
Once the outline of the signal response is checked, restore the AUTO mode so the UNCAL message is cleared.
In Zero Frequency Span mode, sweep time can be set between 100 μs and 1000 sec.

4-8-6. RES. BW [RES. BW] [AUTO]

This key is used to activate resolution bandwitth (IF bandwidth).

AUTO automatically sets resolution bandwidth according to the selected frequency span.

[RES. BW] permits manual setting of resolution bandwidth with DATA controls. A signal response can be separated from its adjacent noise response or two or more signal responses can be separated from each other, by narrowing the resolution bandwidth. The DATA key ([↓]) may be conveniently used to narrow the resolution bandwidth.
When sweep time control is in AUTO mode, sweep time is increased as resolution bandwidth is narrowed.

4-8-7. VIDEO BW [VIDEO BW] [AUTO]

This key is used to activate video bandwidth within 1 Hz to 1 MHz in 1 or 3 sequence.
AUTO automatically sets video bandwidth to the optimum according to the selected frequency span.
Signal responses near the noise level of the analyser will be visually masked by the noise. The video filter can be narrowed to smooth this noise, although a longer sweep time will be required when the video bandwidth is narrowed.

With the video averaging feature shown in page 4-52, which digitally averages the signal responses for each sweep, a better signal-to-noise ratio can be expected with a shorter sweep time. For more details see paragraph 4-14-†. Averaging.

4-8-8. CF STEP SIZE

CF STEP SIZE m AUTO z

This key is used to activate the center frequency step size for center frequency control using ⇩ ⇧.

AUTO automatically sets the step size to one tenth the frequency span. Surveillance of a wide frequency span sometimes requires high resolution. One fast way to achieve this is to take the span in sequential pieces using a tailored center frequency step. This technique is described below:

Set the center frequency and frequency span for the lowest frequency range of the signal response to be measured.

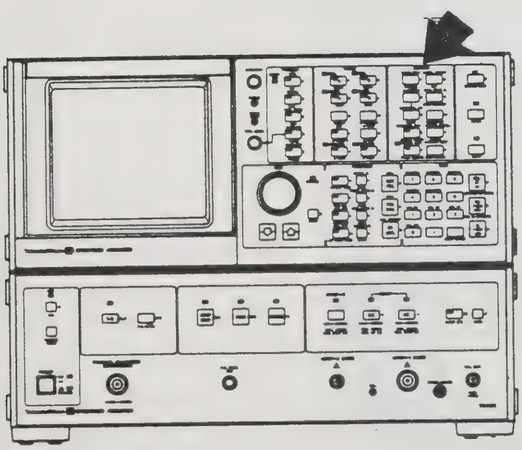
Press CF STEP SIZE and then use the DATA keyboard to enter the same value as the frequency span. Activate the center frequency with CENT. FREQ..

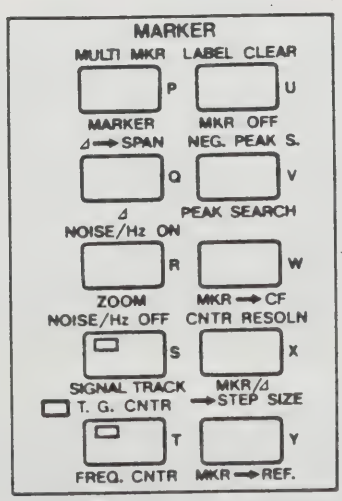
Now each ⇧ sets the center frequency to the next span.

Center frequency step size can also be specified with MKR/Δ →STEP SIZE.

For more details see paragraph 4-9. MARKER.

4-9. MARKER





Use of the MARKER controls increases the speed and accuracy of many measurements. The Multi Marker mode presents up to 10 markers available on the display.

4-9-1. MARKER

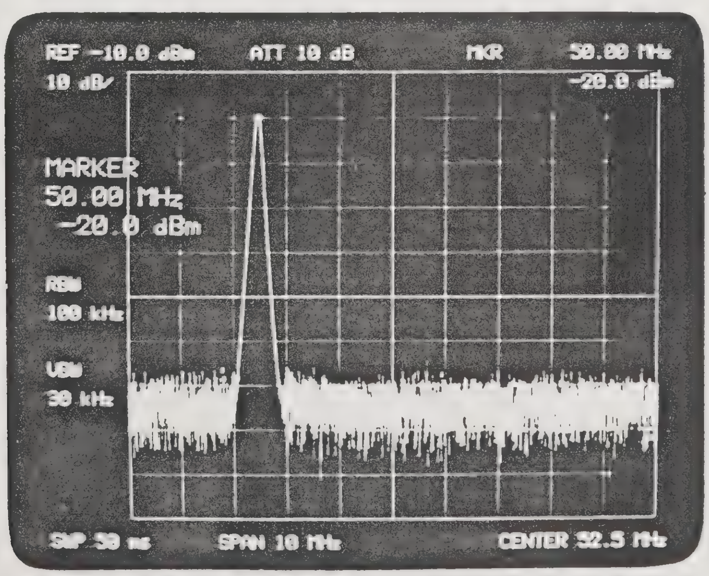
activates a single marker at the center of the display or at the last marker spot.

The frequency and amplitude at the marker will be shown on the active function display area. The same data readouts are presented at the top right corner of the display as well. While the MARKER is normally abbreviated as "MKR" for readout, it is read as "COUNTER" or "CNTR" in the FREQ. CNTR mode or T.G. CNTR mode (to be described later).

An active marker can be moved on a signal response trace with the DATA controls. The DATA knob can continuously control marker position for fine tuning. The DATA step keys move the marker in steps of one division each for faster control.

Use of the DATA keyboard can directly specify the frequency to which the marker is to be positioned. IF a frequency outside the present frequency display range is entered with the DATA keyboard, the marker is positioned to the leftmost or rightmost graticule.

The readouts of marker frequency and amplitude change with the movement of the marker.



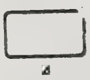
When another function key (such as CENT. FREQ.) is pressed, the marker is deactivated. To activate the marker again press MARKER. A marker which can be controlled with the DATA controls is called an active marker.

When a marker is active, the marker can be positioned on the desired trace by operating the VIEW or WRITE key for the trace memory A, A', B, or B' (see page 4-44).

4-9-2. MKR OFF

Operation of the MKR OFF key clears all markers from the display. If the MARKER key is pressed, a marker will appear again on the last marker spot.

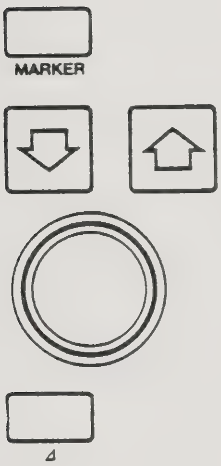
4-9-3. Δ (Delta) Key

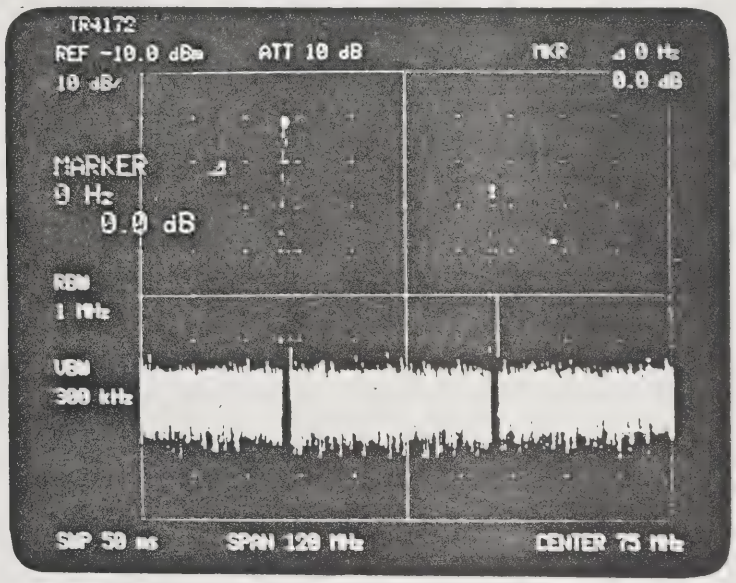


presents two markers on the display. Only one of the two markers is activated and the differences in frequencies and amplitudes of the two markers are read out. The following example shows a measurement of frequency and amplitude differences between two signal responses:

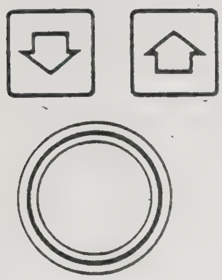
Press MARKER to obtain the normal marker mode in which a marker is activated. Position the marker to the peak of one signal response with .

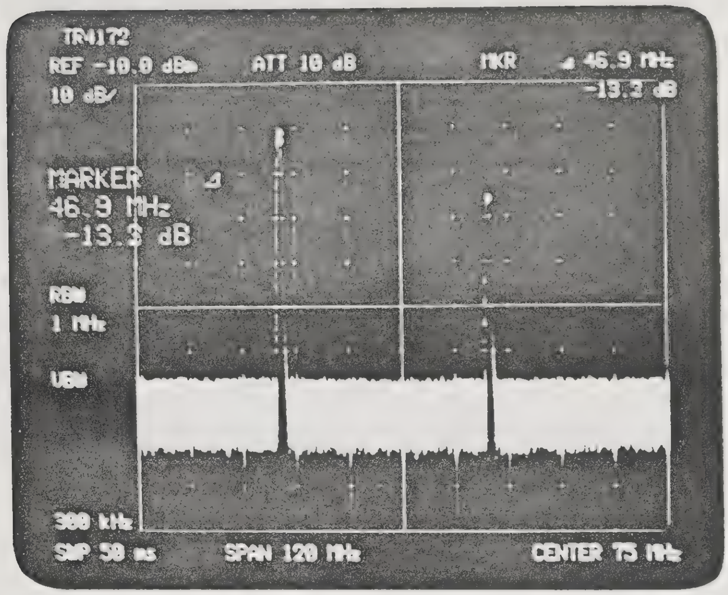
Press . The display will presents a second marker which is active. The first marker is deactivated and remains at the peak of the first signal response. The two markers overlap each other and appear as if a single marker.





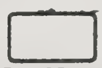
Position the second marker to the peak of the second signal response trace with . Now the differences in the frequencies and amplitudes of the two signal responses are directly read out.



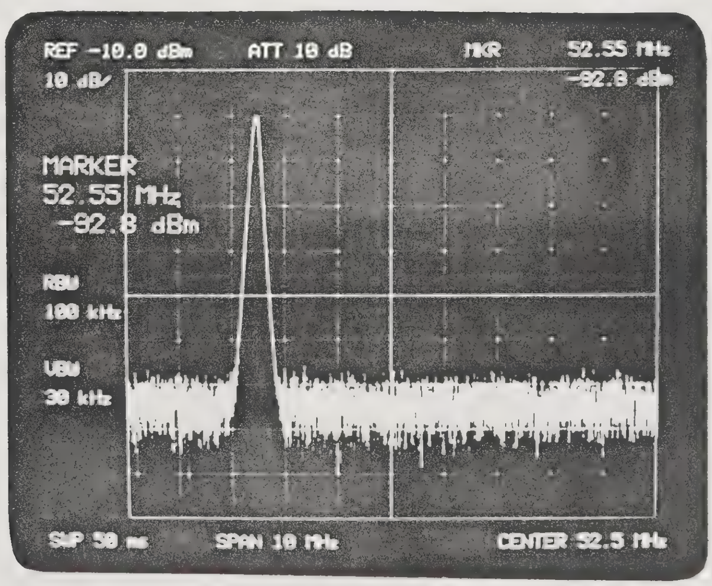


To return the analyzer from delta mode into normal marker mode press the MARKER key. Only one active marker will be left on the display.

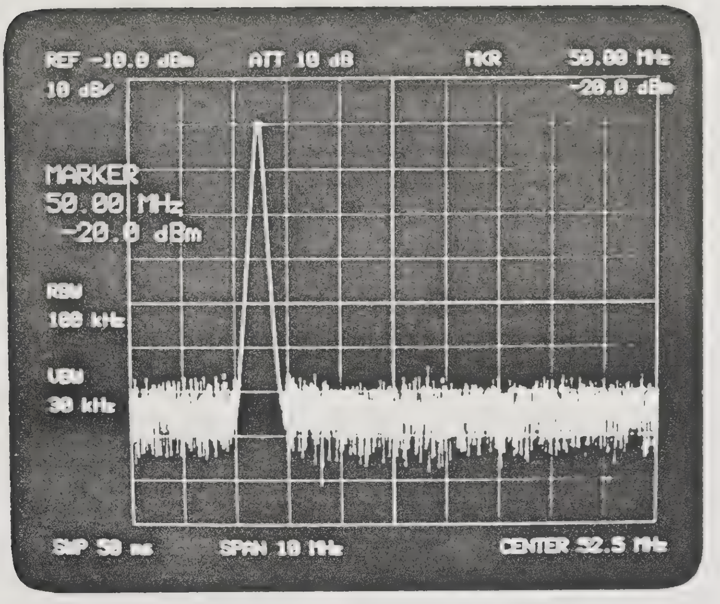
4-9-4. PEAK SEARCH



Operation of th PEAK SEARCH key places a single marker at the peak of the maximum trace response.



PEAK SEARCH



Successive peak search

If SHIFT LABEL PEAK SEARCH are pressed, the analyzer enters successive peak search mode, in which the active marker repeats peak searching after each sweep.

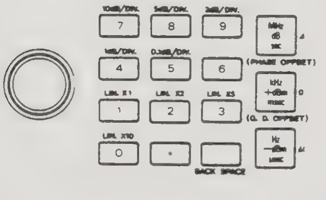
Pressing MKR OFF key cancels the successive peak search mode and erases the marker.

4-9-5. ZOOM

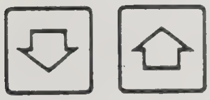
ZOOM

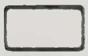
Use of the ZOOM key with the DATA step keys can zoom in a signal specified by a marker. In other words, the zoom operation narrows the frequency span and positions a marker to the center of the CRT display.

In the zoom mode, the DATA controls have functions different from those in other modes.

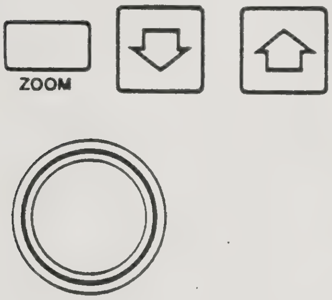


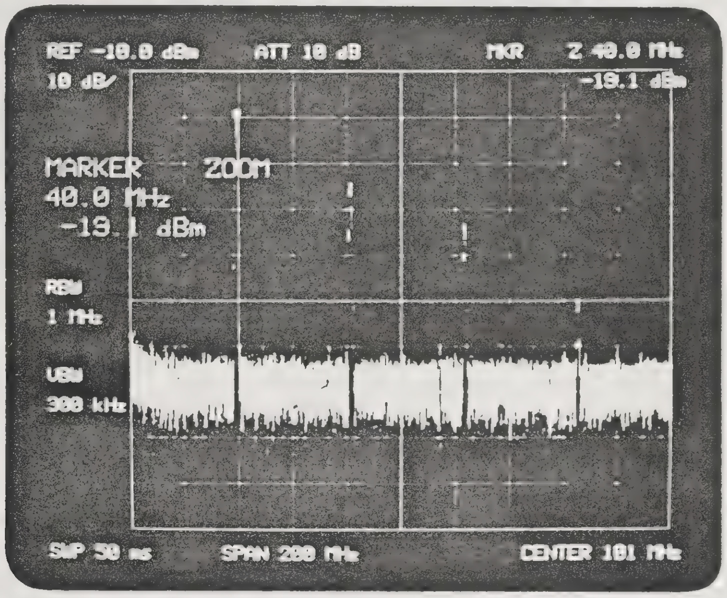
: The DATA knob and DATA keyboard control marker position.

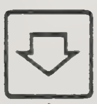
: The Data step keys position a marker to the center of the display while controlling the frequency span.

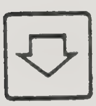


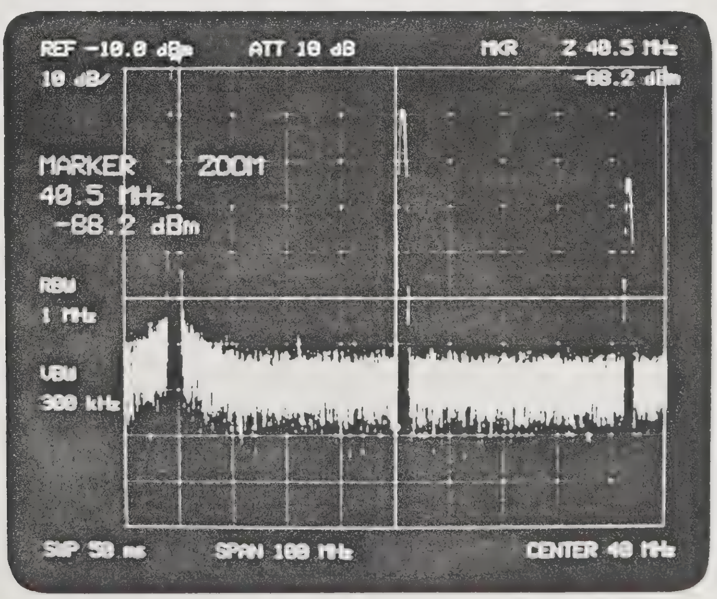
presents an active marker on the display.
Position this marker to the peak of the signal response trace to be measured.

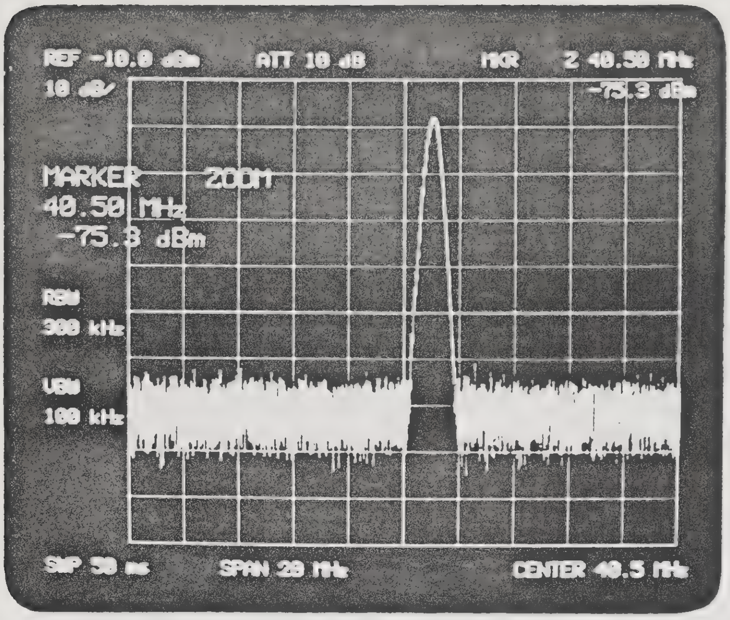




Each time  is pressed, the frequency span is narrowed in 1-2-5 sequences while the marker is moved towards the center of the display.

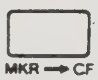






If the marker deviates from the signal peak as shown above, reposition it to the peak with the DATA control.
To return the analyzer from ZOOM mode to normal MARKER mode press the MARKER key.

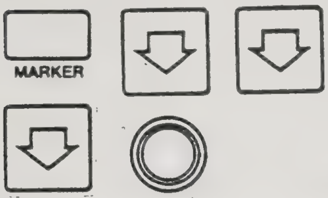
4-9-6. MKR → CF



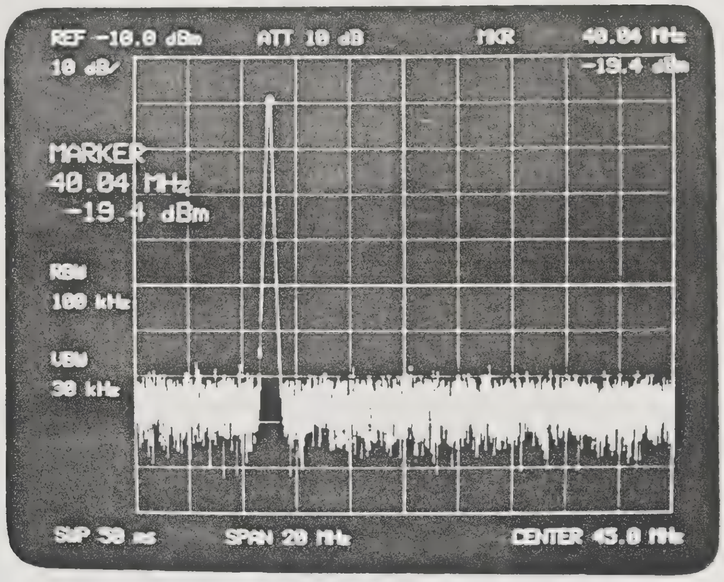
Operation of th MKR → CF key substitutes a marker frequency for a center frequency.

Press 

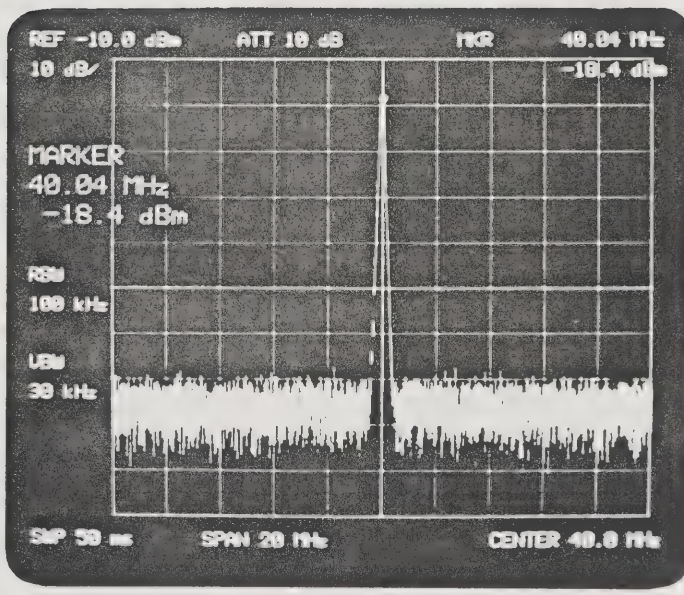
to activate a single marker and then position the marker to the peak of the signal response trace with DATA knob.



The signal frequency is read out as 40.04 MHz.



Press the MKR → CF key. The center frequency is set at 40.0 MHz and the signal response trace is positioned to the center of the display along with the marker.

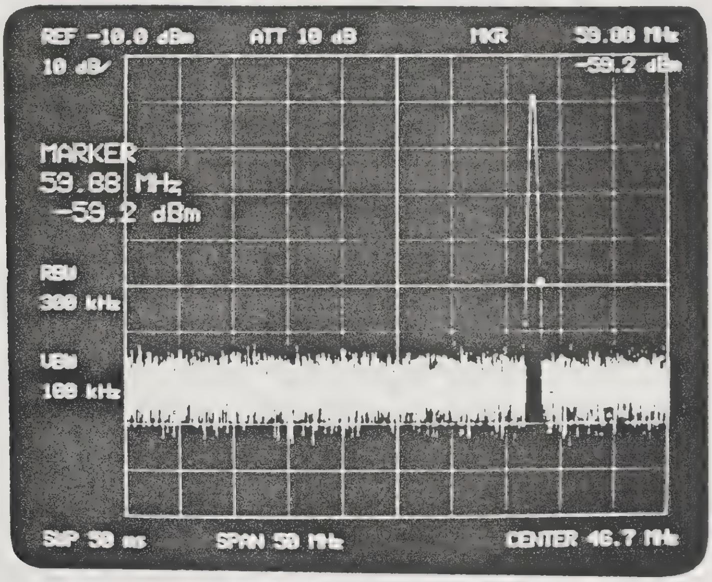


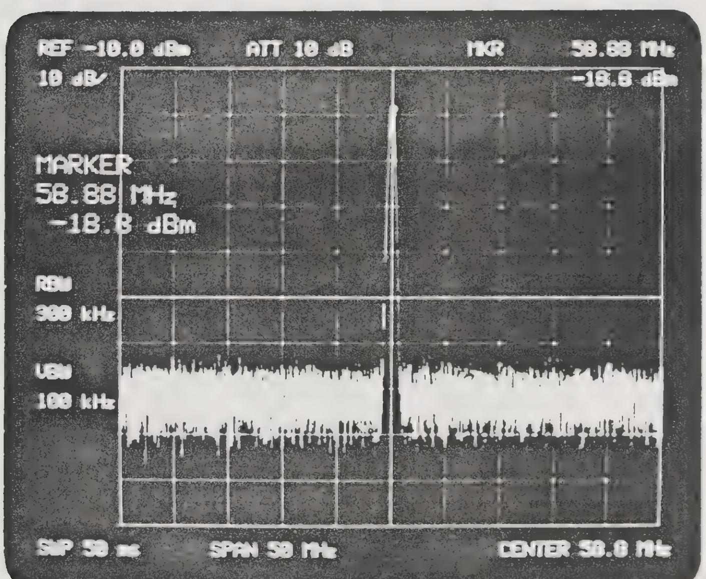
To press the MKR → CF key more than once, wait until the first marker repositioning is finished, then press the MKR → CF key for the second time.

4-9-7. SIGNAL TRACK

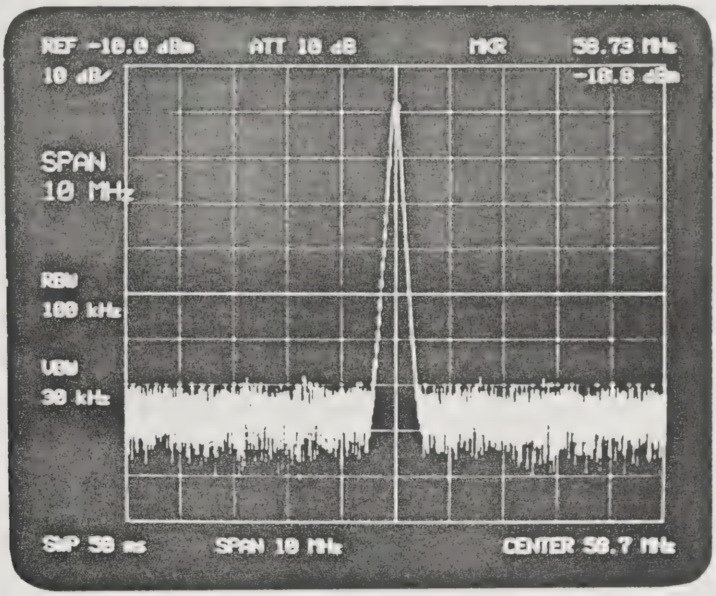
The analyzer can automatically maintain a drifting signal at the center of the display. To operate signal tracking, press  ; the indicator lamp on the key will go on to indicate that the signal tracking mode is entered.

A second depression of the SIGNAL TRACK key will turn off the key indicator lamp and return the analyzer to the normal MARKER mode. Operation of the MARKER, OFF, Δ , or PEAK SEARCH key also clears the SIGNAL TRACK mode and activates the corresponding mode for which the key is pressed.





A drifting signal can be zoomed in in the SIGNAL TRACK mode with [FREQ. SPAN] [⇩] [⇩].



On the above example of the signal tracking mode, the frequency span was narrowed by using the "DATA STEP DOWN" key several times. Instead of using the key, the desired frequency sapn can be directly entered from the DATA keyboards. After the entry of the narrower frequency span by the DATA keys, the signal is zoomed step by step, tracking the signal at the center of the display. During this zooming of the signal tracking mode, "AUTO ZOOM" is displayed at the active function area, and all the keys but the [SIGNAL TRACK] and [MKR. OFF] keys are inoperative until the zooming stops. To stop the auto zooming on the signal tracking mode, use either of the above two switches.

4-9-8. MKR/Δ → STEP SIZE

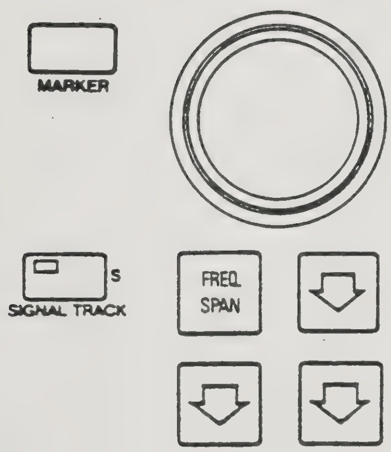
MKR/Δ →STEP SIZE

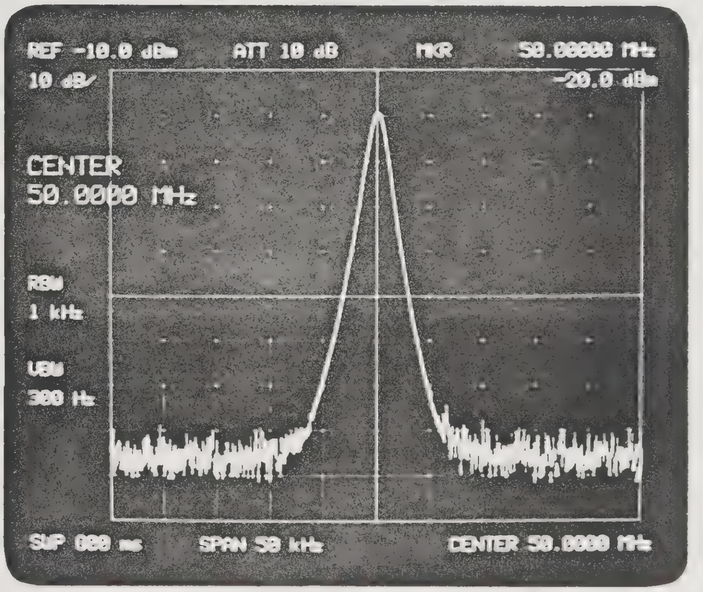
(1) In the normal MARKER mode, operation of the MKR/Δ →STEP SIZE key substitutes marker frequency for center frequency step-size data.

(2) In the DELTA MARKER mode, operation of the MKR/Δ →STEP SIZE key substitutes frequency difference between two markers for center frequency step size data.

(3) Center frequency can be controlled in steps with CENT. FREQ. and ⇩ ⇧ with the step size determined in above steps (1) or (2).

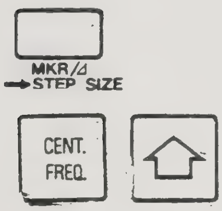
For example, when measuring a fundamental wave and its higher harmonics, press MARKER switch to activate a single marker and position it to the peak of the fundamental wave.
Then use the SIGNAL TRACK, FREQ. SPAN, and DATA step keys to zoom in on the fundamental wave at the center of the display.

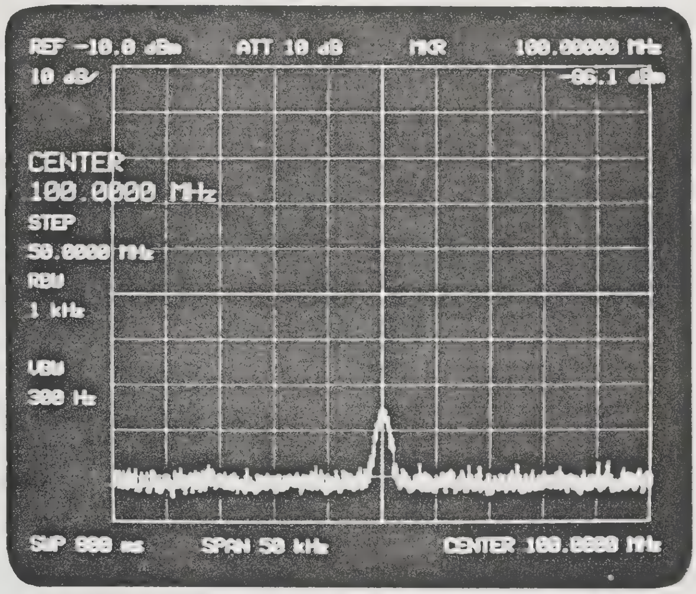




Next press the MKR/Δ → STEP SIZE key to substitute the marker frequency (fundamental wave frequency) for the center frequency step size; the indicator lamp on the CF STEP SIZE key will light. Press the CENT. FREQ. key to activate center frequency, then press  . The center frequency is doubled and the second harmonic can now be observed.

Each time  is pressed subsequently, the third, fourth, and subsequent harmonics can be observed.





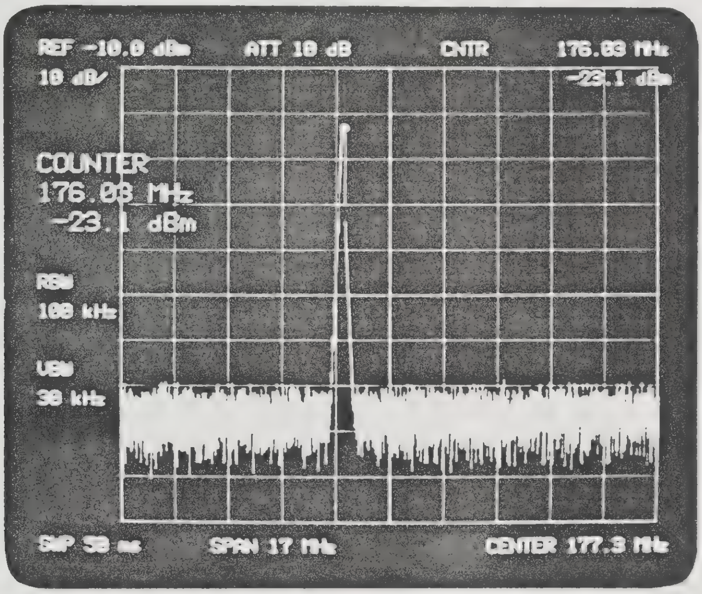
4-9-9. T.G. CNTR SHIFT T. G. CNTR

The T.G. CNTR mode counts the frequency of signals with great precision and accuracy. To activate the T.G. CNTR mode press SHIFT T. G. CNTR ; the T.G. CNTR indicator lamp lights.

In the normal MARKER mode marker frequency is calculated from the marker position on the graticule and the center frequency, whereas in the T.G. CNTR mode, marker frequency is directly counted by the built-in counter.

Marker frequency is read as CNTR XXX Hz at the top right corner of the display. To return the analyzer to the normal MARKER mode press SHIFT T. G. CNTR a second time; the T.G. CNTR indicator lamp will go off.

SHIFT T. G. CNTR



In the T.G. CNTR mode the resolution of the counter can be increased up to 1 Hz as follows:

Press the SHIFT key and then the FREQ. CNTR key to activate the T.G. CNTR mode. Then press SHIFT CNTR RESOLN . The display will show message COUNTER RESOLN.

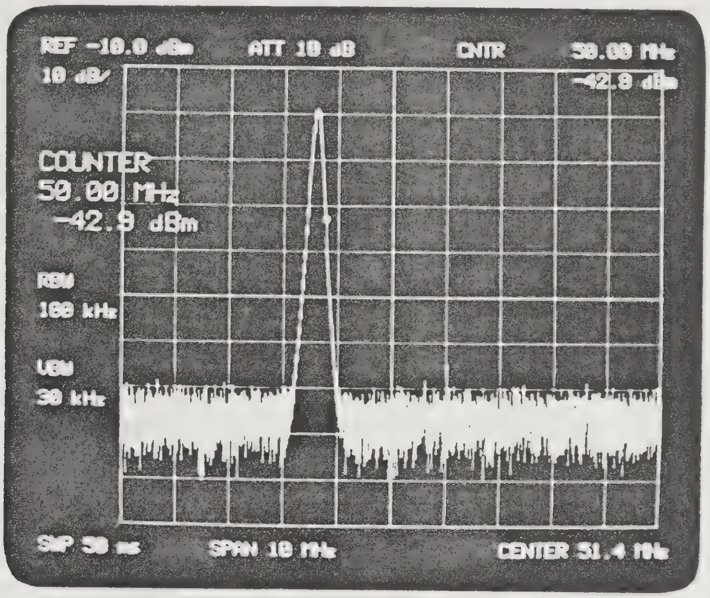
Now enter the desired resolution data (least significant digit) from the DATA keyboard.

Note that an excessively high counter resolution causes an extended gate time and hence delayed display writing. Also note that signal tracking is not usable in the T.G. CNTR mode.

4-9-10. FREQ. CNTR [FREQ. CNTR]

Operation of the [FREQ. CNTR] keys activates FREQ. CNTR mode; the indicator lamp on the key will light.
The FREQ. CNTR mode permits precision measurement of the frequency of a signal (on which a marker is positioned) the level of which is more than 15 dB higher than the noise level. For the measurement the marker need not be positioned at the signal peak.

[FREQ. CNTR]

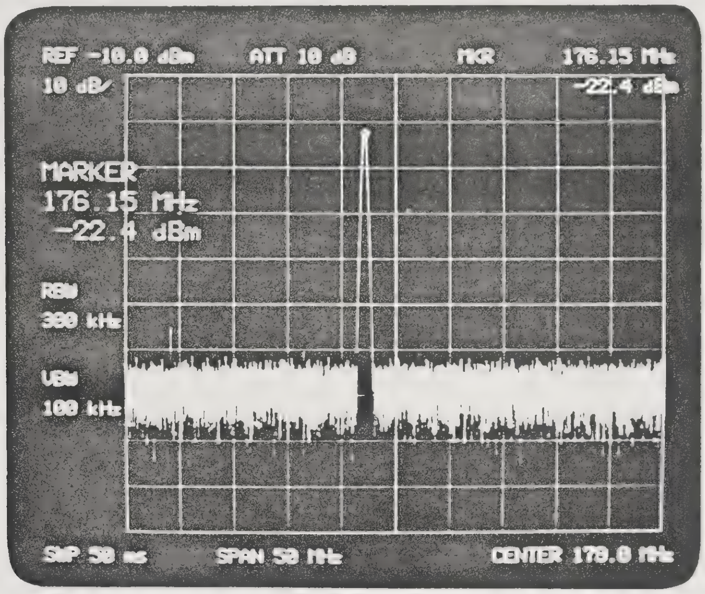


The frequency readout indicates not the marker frequency but the frequency of the signal on which the marker is positioned, though the amplitude readout indicates the amplitude at the marker.
In the FREQ. CNTR mode the title for frequency and amplitude readouts is COUNTER or CNTR, which is the same as that in the TG CNTR mode.
To increase the frequency counter resolution, press [SHIFT] [CNTR RESOLN] and then enter the desired resolution data (least significant digit to be read) from the DATA keyboard. To return the analyzer from the FREQ. CNTR mode into the normal MARKER mode press [FREQ. CNTR] again. The indicator lamp on the key will go off to indicate that the normal MARKER mode is restored.

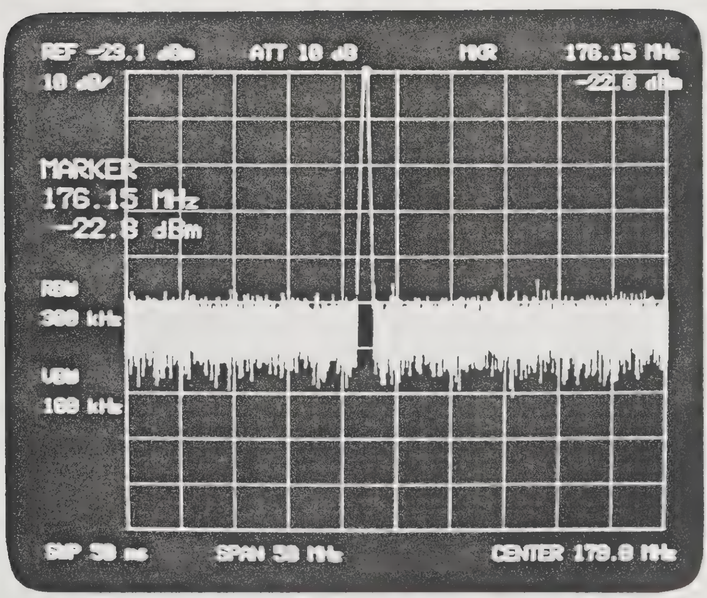
4-9-11. MKR → REF.

MKR → REF.

This key is used to substitute the amplitude at a marker for a reference level [REF. LEVEL].



MKR → REF.



4-9-12. Multi Marker Mode

SHIFT   MULTI MKR / MARKER

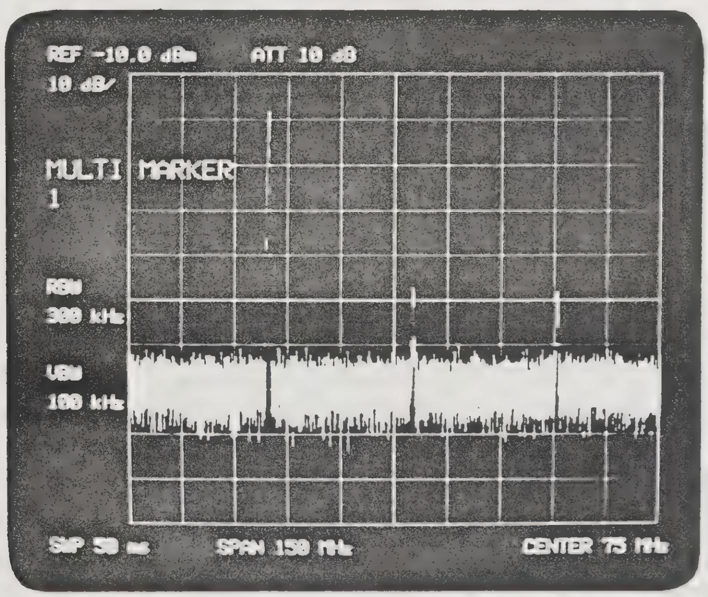
The Multi Marker mode allows the display to present more than one and up to ten markers at a time.

If SHIFT MULTI MKR are pressed, "MULTI MARKER" will be shown on the active function display area. Use the DATA keyboard to enter the number of markers to be displayed.

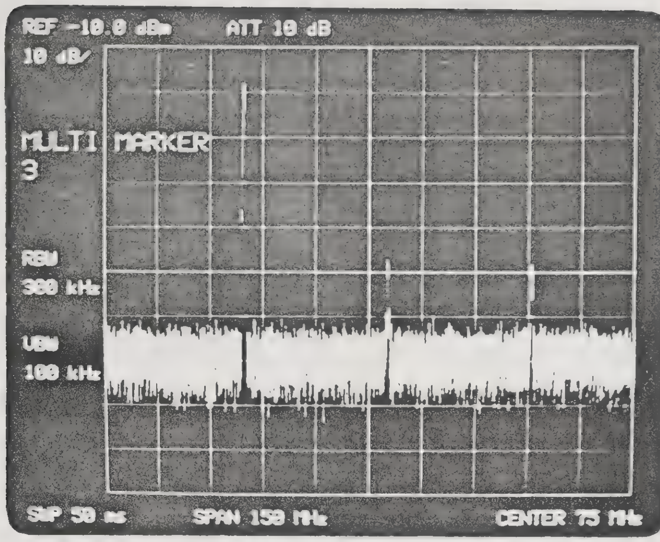
Then press the Hz key to register the entry data as the number of markers. Markers are presented on the display up to the programmed number each time the MARKER key is pressed. The following example shows display of three markers:

Press SHIFT MULTI MKR, then enter 3 Hz from the DATA keyboard. When the MARKER key is pressed the first time the first marker appears on the display. Position the marker to the desired signal response trace. The frequency and amplitude at the marker are shown on the active function display area and at the top right corner of the display. The second and third markers appear on the display when the MARKER key is pressed a second and third time respectively.

Set up the analyzer for Multi Marker mode with SHIFT MULTI MKR.

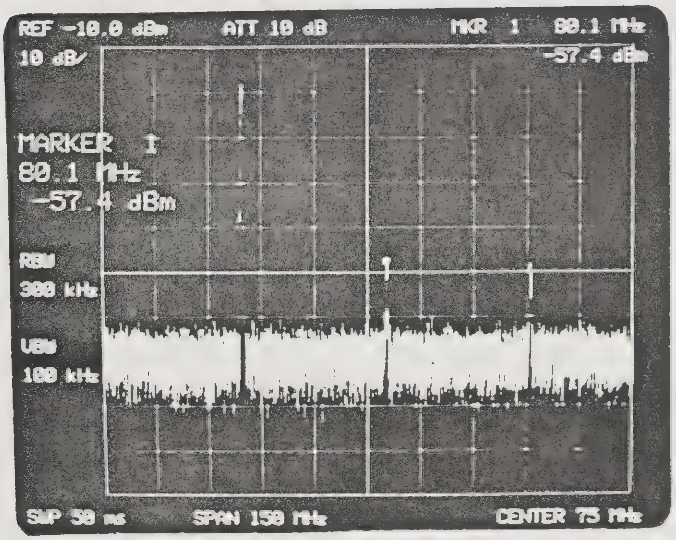


Set the number of markers to 3 with [3] [Hz / −dBm / µsec].

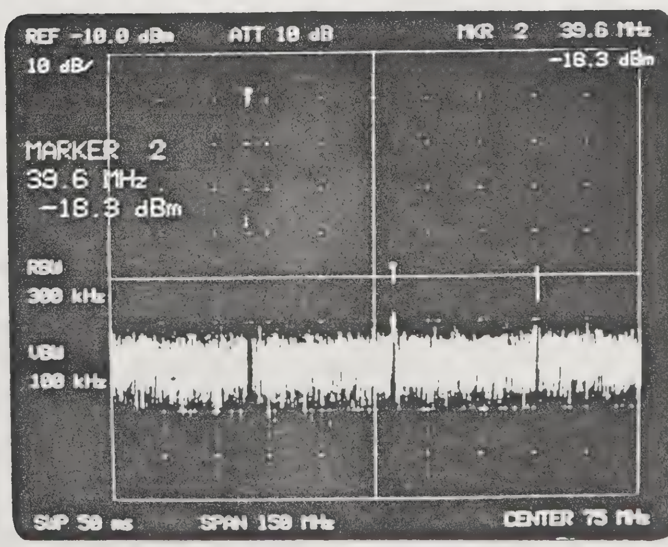


Activate the first marker (MKR 1) with [ ] MARKER and place the marker on a signal with

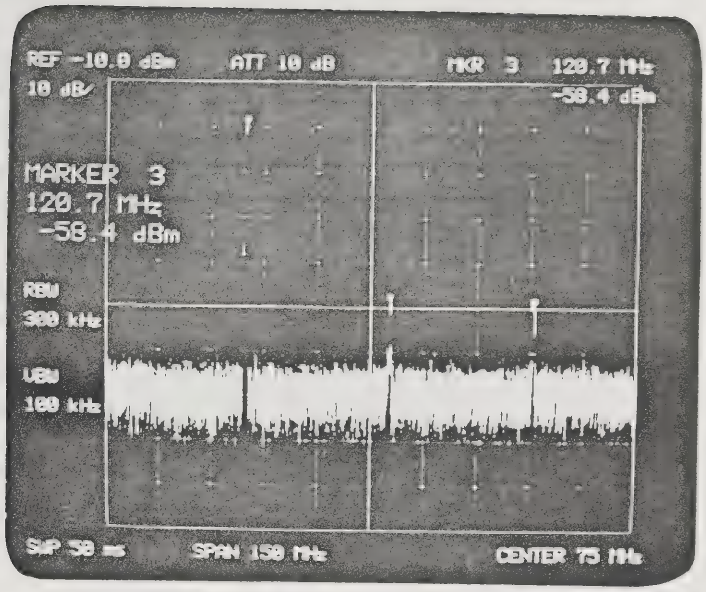

.



Generate the second active marker (MKR 2) with [ ] MARKER. The first marker is deactivated.



Generate the third active marker (MKR 3) with MARKER .



Now there are three markers presented on the display. Subsequent operations of the MARKER key will activate the three markers successively.

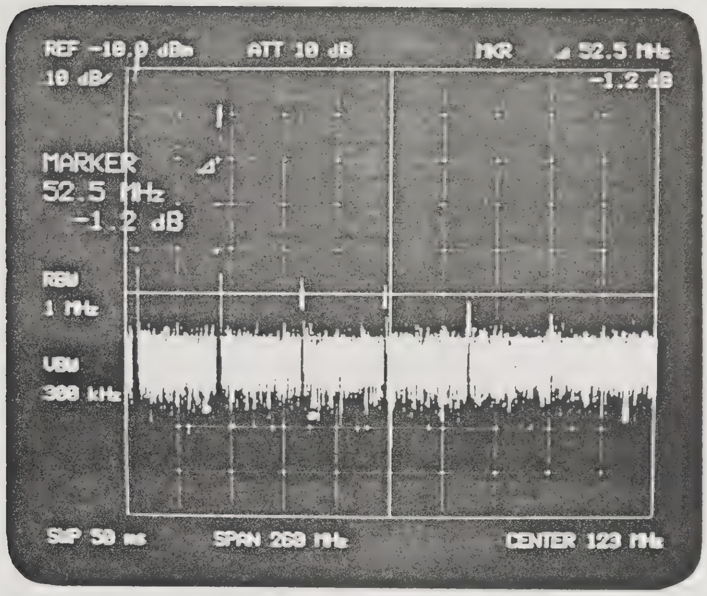
An active marker is highlighted. Operation of the MKR OFF key erases all markers from the display, yet the last positions of the markers and the programmed number of multi markers are left in the internal memory. So the markers can be recalled on the display one after another each time the MARKER key is pressed. To change the programmed number of multi markers press SHIFT MULTI MKR , then enter the new number of markers (between 1 and 10) from the DATA keyboard before pressing the Hz key.

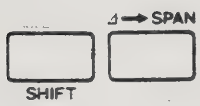
To return the analyzer from Multi Marker mode into the normal MARKER mode, set the number of multi markers to 1 with

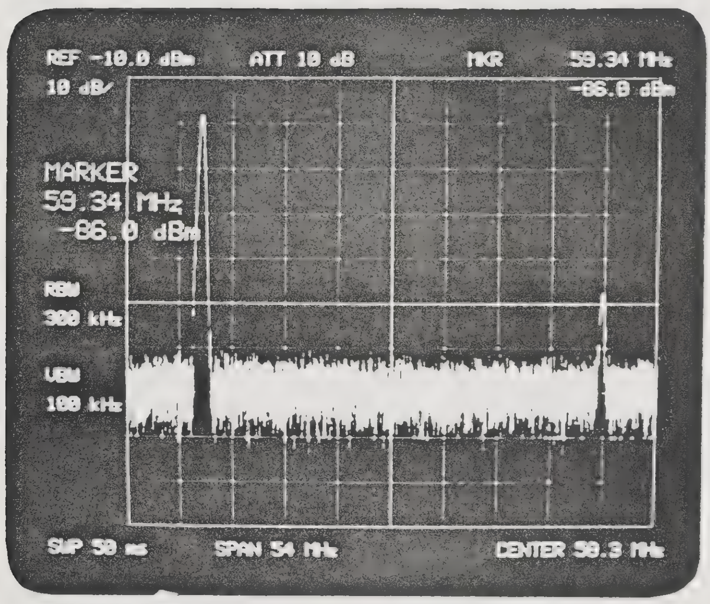
SHIFT MULTI MKR/MARKER 1 Hz/-dBm/usec .

4-9-13. Δ → SPAN

If SHIFT Δ→SPAN are pressed when the analyzer is in the Delta Marker mode, the center frequency and frequency span are set so that the frequency range between two markers occupies the entire frequency span. In this case the two markers need not be active.



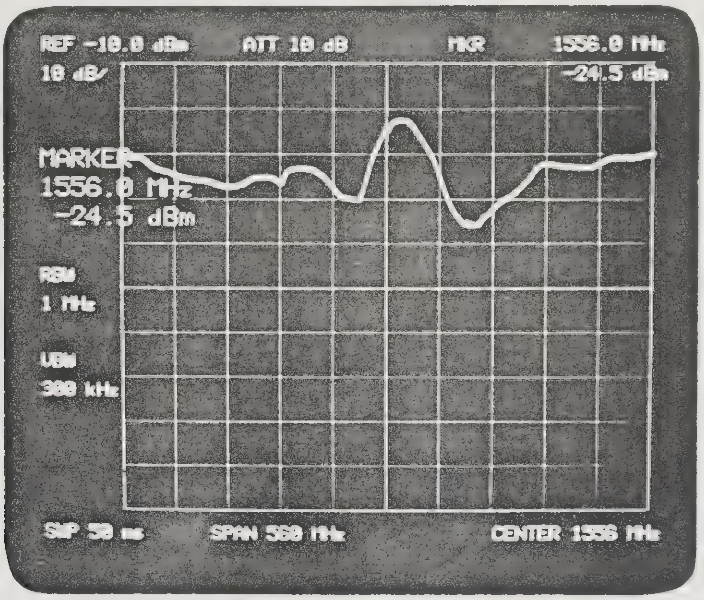


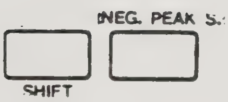


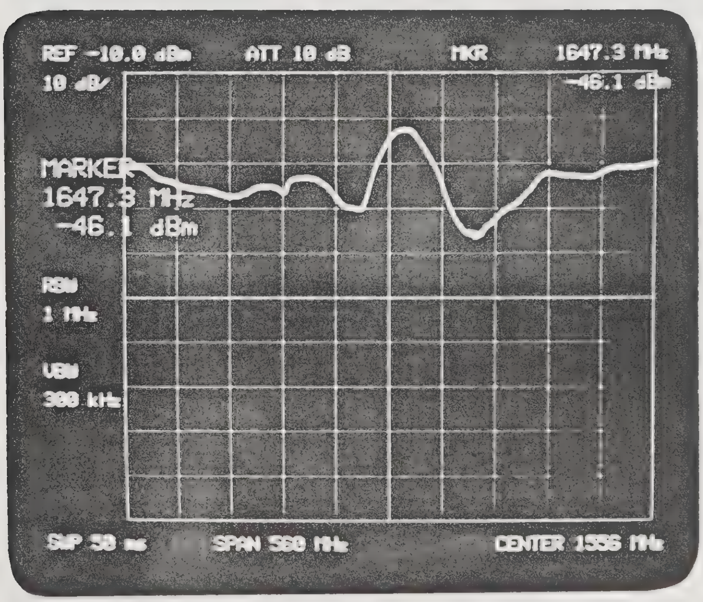
The analyzer is returned from the Delta Marker mode to the normal MARKER mode with a marker appearing at the center of the display.
The frequency span is slightly greater than the difference in the two marker frequencies (Δ).
The center frequency is set at the left-side marker frequency plus span/2.
In the Delta Marker mode the Δ → SPAN key is operative irrespective of whether the left or right marker is active.

4-9-14. NEG. PEAK S.

Operation of the SHIFT and NEG. PEAK S. (Negative peak search) keys places an active marker at the bottom of the lowest signal response trace.







4-9-15. Noise Level Measurement (Noise/Hz)

When noise level measurement is activated and the marker is placed in the noise, the rms noise level is read out normalized to a 1 Hz noise power bandwidth. To activate the noise level measurement press

[SHIFT] [NOISE/Hz ON R].

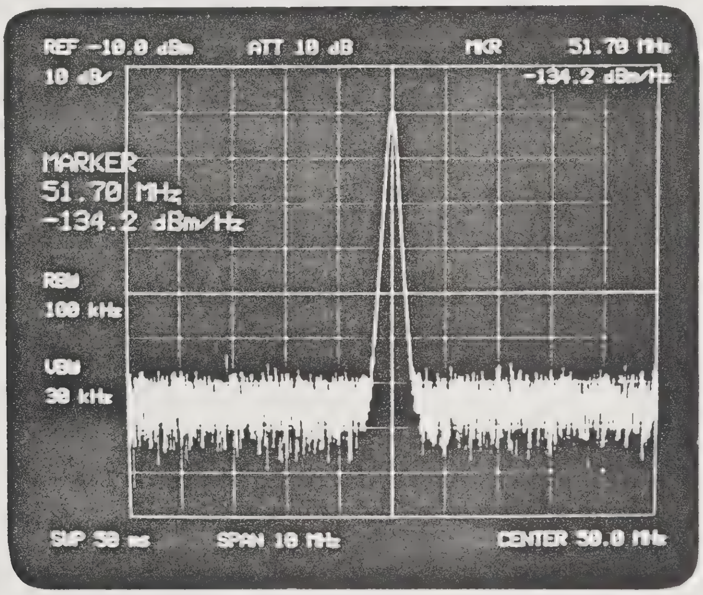
The marker level readout on the display reads XX dBm/Hz, indicating the noise level measurement mode. To obtain a noise level over a bandwidth greater than 1 Hz, add the following value to the readout:

$$10 \log_{10} \left(\frac{\text{bandwidth}}{1 \text{ Hz}}\right)$$

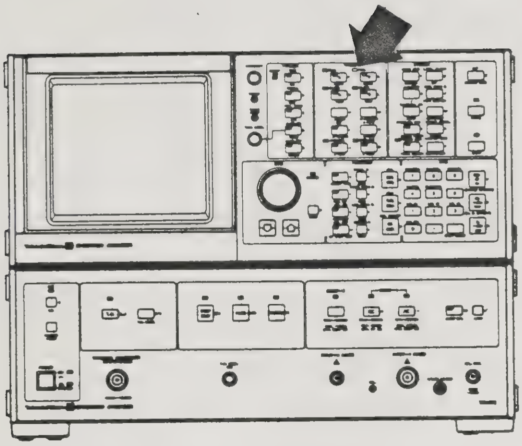
To return the analyzer from the noise level measurement mode to the normal MARKER mode, press [SHIFT] [NOISE/Hz OFF S].

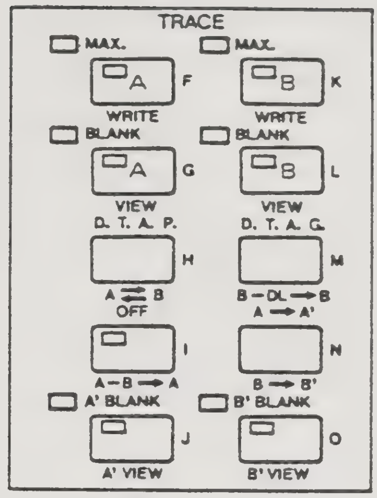
NOISE/Hz ON

SHIFT R



4-10. TRACE





In the TRACE mode, up to four different signal response traces are converted to the corresponding digital information and stored in internal trace memories which can then be transferred to the CRT display. The trade memory consists of memories A, A', B, and B'. Memories A' and B' are auxiliary to memories A and B respectively. This section describes the basic operating procedures in the TRACE mode, then presents simultaneous four trace display.

4-10-1. Basic Operation Procedures in TRACE mode

(1) WRITE and VIEW

WRITE and VIEW keys are provided for memories A and B.
When the WRITE key is pressed, the analyzer signal response is written into trace memory during the sweep and the memory contents are displayed on the CRT.
As a result, the signal response trace on the CRT varies with sweep rate.
When the VIEW key is pressed, no updating of the trace memory is made and the result of the latest sweep is saved and displayed on the CRT.

The WRITE mode can be selected for only either of memory A or memory B at a time.
Memories A' and B' have only VIEW keys and have no WRITE keys. The A → A' (B → B') key is used to write information into memories A' and B', respectively.

a. WRITE A

   When the WRITE A key is pressed, the analyzer signal response is written into trace memory A during each sweep and the memory contents are displayed on the CRT. The indicator lamp on the WRITE A key goes on to indicate the WRITE A mode. When the analyzer is initially switched on or the MASTER RESET key is pressed, the instrument is automatically placed in the WRITE A mode.

b. VIEW A

   If the VIEW A key is pressed in the WRITE A mode, updating of trace memory A is no longer made and the current memory data is displayed on the CRT.
   If the VIEW A key is operated in the BLANK A mode (to be described later), the contents of trace memory A is recalled on the CRT.

c. WRITE B

   When the WRITE B key is pressed, the analyzer signal response is written into trace memory B during each sweep and the memory contents are displayed on the CRT.
   The indicator lamp on the WRITE B key goes on to indicate the WRITE B mode.
   The WRITE mode can be selected for only either of memory A or memory B at a time. The memory for which the WRITE key is pressed most recently is placed in the WRITE mode. If the WRITE B key is pressed in the WRITE A mode, memory A is placed in the VIEW A mode and memory B is placed in the WRITE B mode. In this case, active contents of memory B are overlapped on stationary trace A.

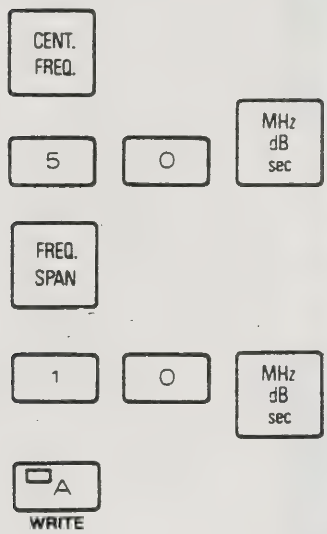
d. VIEW B

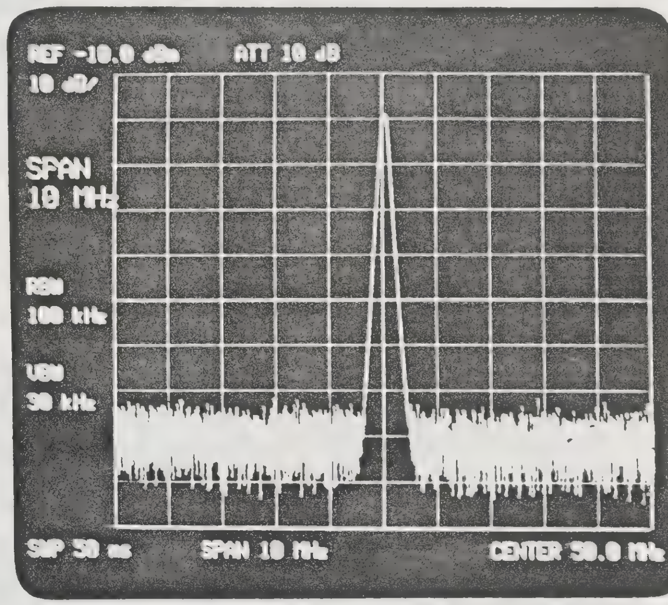
   If the VIEW B key is pressed in the WRITE B mode, updating of trace memory B is no longer made and the current memory data is displayed on the CRT.

e. Example of WRITE and VIEW mode usage

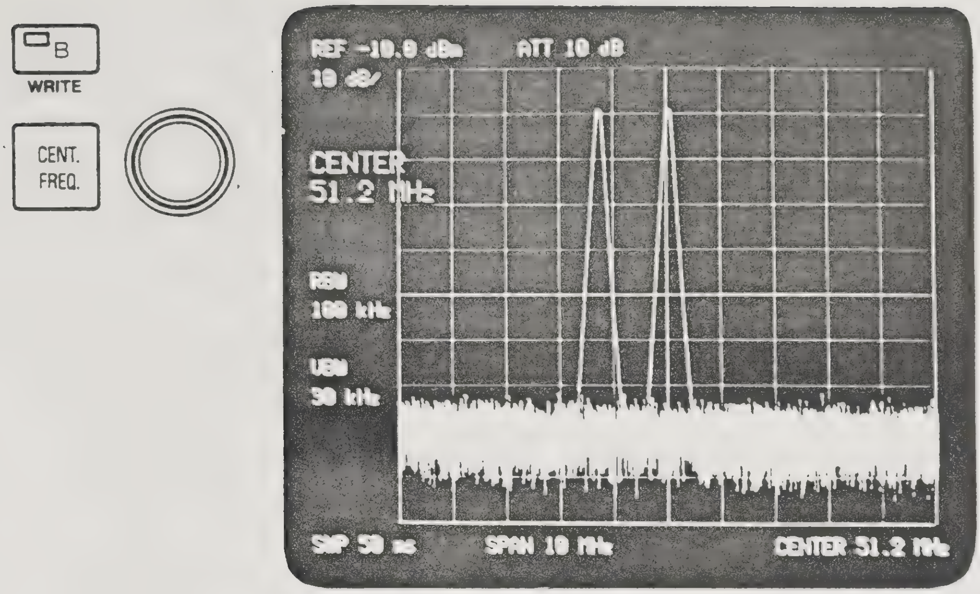
A simple example of the WRITE and VIEW mode usage using the CAL. OUT. signal is described below:

Press the AC key for INPUT-1. Connect the CAL. OUT. connector to the INPUT-1 connector with the supplied input cable MI-02 (with he N-BNC adapter JUG-201A/U attached to the INPUT-1 connector). Set the CENT. FREQ. to 50 MHz and FREQ. SPAN to 10 MHz. IF the analyzer is not in the WRITE A mode press the WRITE A key.

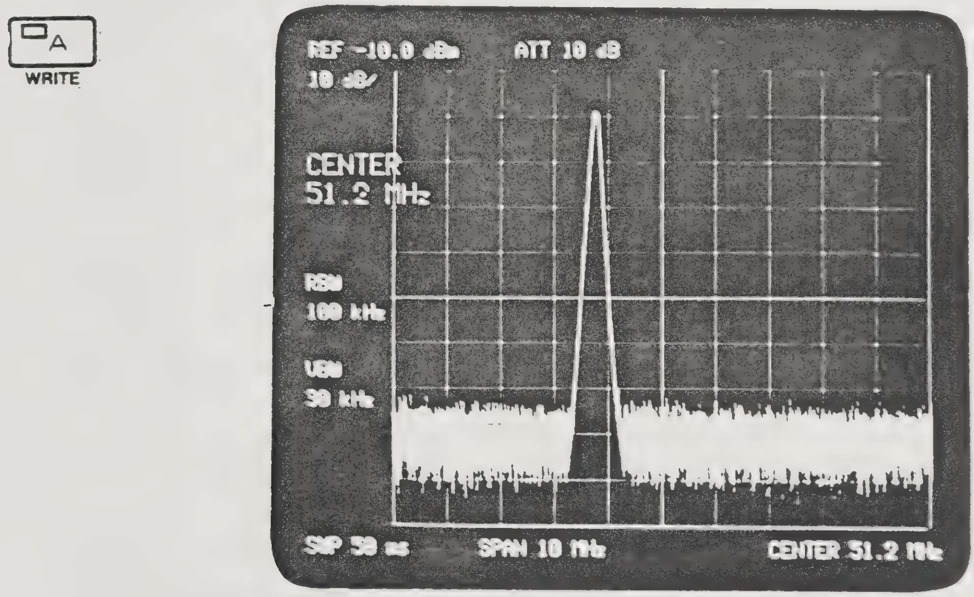




Then press the WRITE B key. Trace memory B is placed in the WRITE mode and memory A is placed in the VIEW mode with trace A frozen. Press the CENT. FREQ. key and adjust the DATA knob. Active trace B can now be observed together with inactive trace A.



Press the WRITE A key again to select the WRITE A and VIEW B mode. Trace A is now overlapped with frozen trace B.



f. B → B', A → A', VIEW A', VIEW B'

These keys are used to transfer the contents of memory B to memory B' or those of memory A to memory A'.

Pressing B'VIEW B → B' transfers the contents of memory B to memory B'.

Each trace is generated from 1001 points across the graticule. Odd numbered 500 points out of the 1001 points of trace B are written into memory B'. Even numbered 501 points leave in memory B.

A' VIEW SHIFT B → B' stores the contents of memory A in memory A'. The odd numbered 500 points out of the 1001 points of trace A are transferred to memory A', and the even numbered 501 points of trace A are left in memory A.

Be sure to press A' VIEW or B' VIEW before pressing B → B'.

(2) MAX.

In the MAX. mode the maximum signal response is held and displayed. At the end of each sweep, the new data is compared with old data in memory at each 1001 point and a larger signal response is stored in memory.

Operation of SHIFT MAX. A selects the MAX. A mode and the MAX. indicator lamp lights. Operation of SHIFT MAX. B selects the MAX. B mode.

The MAX. mode can be cleared by pressing the WRITE, VIEW or BLANK key for the pertinent memory.

(3) BLANK

BLANK A BLANK B A' BLANK B' BLANK

Unnecessary traces can be blanked from the CRT by using BLANK keys.

To blank trace A from the CRT, press SHIFT BLANK A to place memory A in the BLANK mode.

Since the contents of the momory are saved in the BLANK mode, they can be recalled on the CRT by pressing the VIEW key. The BLANK mode can be selected for memories B, A', and B' in much the same way.

If the BLANK key is pressed in the WRITE mode, updating of the memory is no longer made and the current memory data is saved, with the CRT blanked out.

If the BLANK key is pressed in the VIEW mode, a frozen trance is blanked from the CRT and is saved in memory.

The BLANK mode can be cleared by pressing the VIEW, WRITE or MAX. key.

If the VIEW A key is pressed in the BLANK A mode, the saved trace is recalled on the CRT. This procedure can be applied to memories B, A', and B' as well.

If the WRITE A key is pressed in the BLANK A mode, the analyzer is placed in the WRITE A mode and the saved memory data is erased from memory A, and the signal response is written into the memory at the sweep rate and then transferred to the CRT (same for memory B as well).

As mentioned earlier, when VIEW A' mode is selected with A' VIEW SHIFT A → A', only the even numbered 500 points (out of 1001 points) of trace A are transferred to the CRT. To display the full 1001 points of trace A again, press SHIFT A' BLANK to blank trace A' from the CRT, then press the WRITE A key.

(4) Trace exchange

A ⇄ B exchanges the contents of trace memories A and B. The contents of memories A' and B' are also exchanged at the same time.

(5) Trace subtraction

a. A-B → A

A-B → A subtracts the contents of memory B from those of memory B are subtracted from trace A from sweep to sweep and memory A or trace A and stores the result in memoty A.

If A-B → A is pressed in the WRITE A mode, the contents of the resulting trace is displayed. The indicator lamp on the A-B → A key lights to indicate the A-B → A mode.

If A-B → A is pressed in the VIEW A mode, the contents of memory B is subtracted from frozen trace A and the result is written into memory A and then transferred to the CRT. The indicator lamp on the A-B → A key momentarily lights and memory A remains in the VIEW A mode.

If A−B → A is pressed in the WRITE B mode, memory B is placed in the VIEW B mode and the contents of memory B are subtracted from those of memory A and the result is written into memory A. The indicator lamp on the A−B → A key momentarily lights.

A WRITE A−B → A selects the A-B → A mode, and SHIFT clears the A-B → A mode to return the analyzer to the normal WRITE A mode.

b. B-DL → B

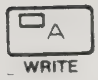
First place memory B in VIEW B mode. Then, press B−DL → B. The display line level (to be described later) is subtracted from the contents of memory B (amplitudes at each point). If B-DL → B is pressed in the WRITE B mode, memory B is placed in VIEW B mode.

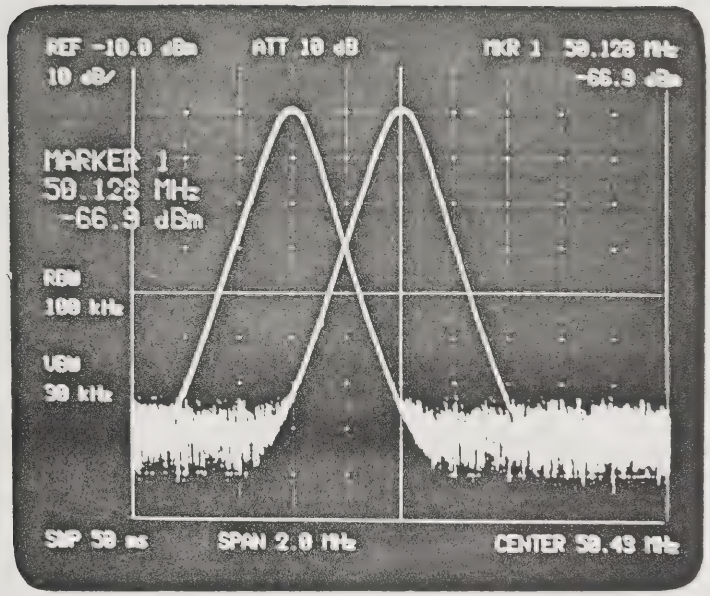
(6) Markers on memories A, B, A' and B'

If the WRITE or VIEW key for memory A or B or the VIEW key for memory A' or B' is pressed when an active marker is present on the CRT, the marker is repositioned to the memory for which the corresponding key is pressed. At this time the marker position on the horizontal graticule line remains unchanged. An inactive marker remains in its home memory even when one of the above keys is operated.

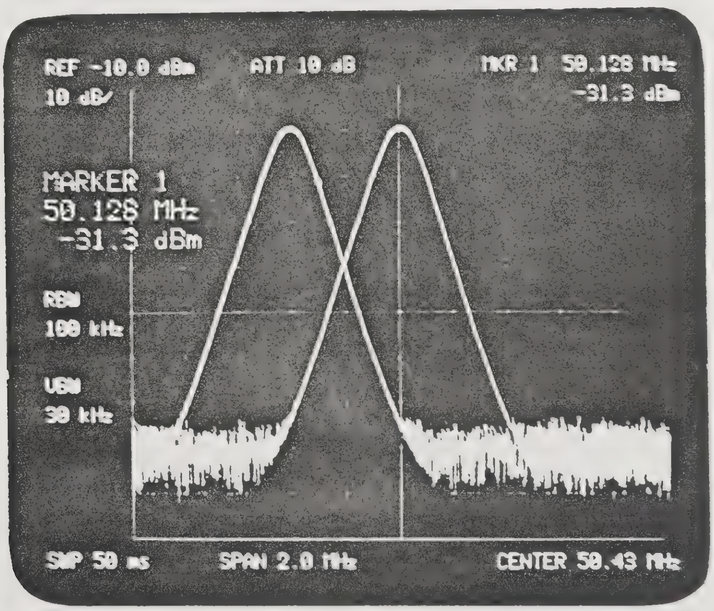
If one of memories A, B, A' or B' is placed in the BLANK mode, the marker for that memory is also blanked from the CRT. Marker repositioning is described below:

- Memory trace A (right) and memory trace B (left) are present on the display (see photo). Memories A and B are placed in the WRITE A and VIEW B modes respectively and an active marker is present on memory trace A.





If the VIEW B key is pressed the active marker is repositioned on trace B.



The marker moves on stationary trace B with the rotation of the DATA knob.
If the WRITE A key is pressed the marker is again repositioned onto trace A.

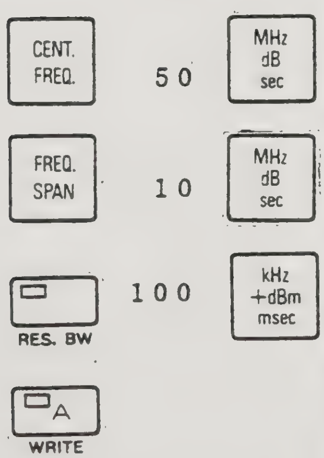
By utilizing this characteristic, differences in frequency and level between two traces can be read with a delta marker.
The reading procedure is described in the following:
First, activate a marker on a trace and position it to the desired position, then press [Δ]. Press a trace key (e.g. [B] VIEW) to reposition the active marker on the other trace, then position it to the desired position on that trace.
The differences in frequency and level between the two traces are now read out. Note, however, that those frequency and level differences are calculated from the setup conditions (frequency span, dB/div., etc.) currently shown on the display.

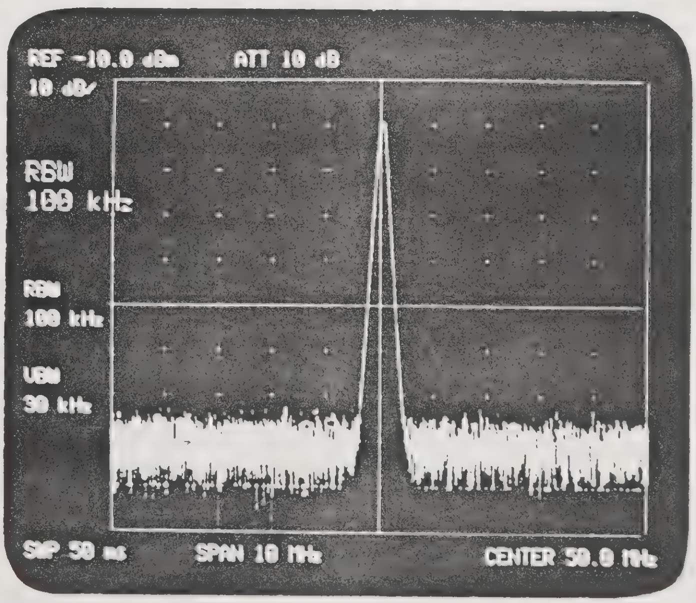
4-10-2. Simultaneous Four Trace Display

An example of simultaneous four trace display using the 50 MHz CAL. signal is given below.

(1) Press the AC key for INPUT-1. Connect the CAL. OUT. connector to the INPUT-1 connector with input cable MI-02 (with the N-BNC plug adapter attached to INPUT-1).

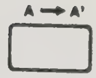
(2) Set the center frequency to 50 MHz. The CAL. signal will appear at the center of the display.
Set frequency span to 10 MHz and resolution bandwidth to 100 kHz. Press the WRITE A key.





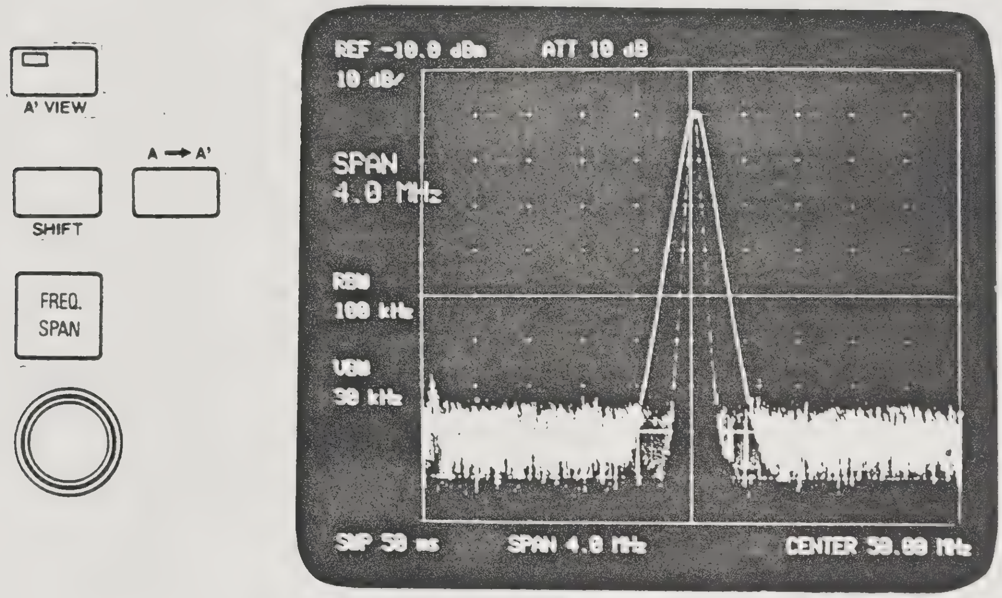
(3) Press 

and 

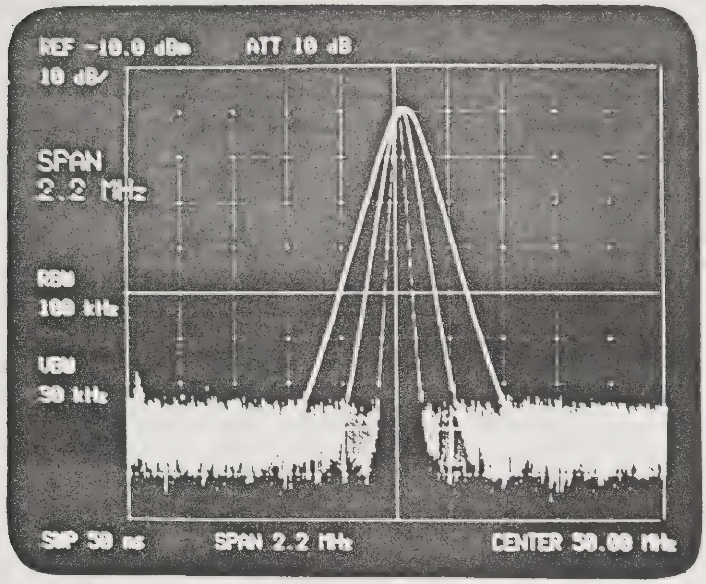


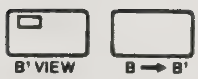
. The contents of memory A is transferred to memory A'. Traces A and A' cannot so far be discriminated from each other since the contents of memories A and A' are identical.

(4) Press the FREQ. SPAN key and then turn the DATA knob slightly counterclockwise to enlarge the trace. Now active trace A can be discriminatad from frozen trace A' on the display.



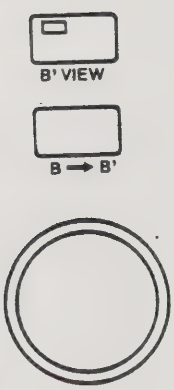
(5) Press the WRITE B key. Memory A is automatically placed in the VIEW A mode and trace A is frozen. Memory B can now be updated. Turn the DATA knob to enlarge trace B. Now three traces B, A, and A' are displayed.

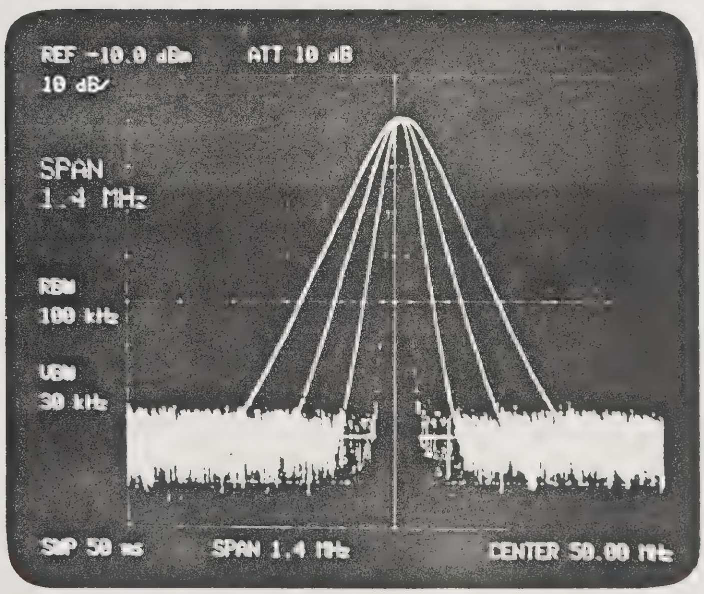


(6) Press 

to transfer the contents of memory B to memory B'. Trace B cannot be discriminated from trace B' since the contents of memories B and B' are identical.

(7) Turn the DATA knob slightly counterclockwise to discriminate trace B' from trace B. Now four traces are displayed on the CRT at a time.





(8) Use the BLANK key to blank unnecessary trace from the display:

B' BLANK

[ ] [ ] blanks trace B'.

SHIFT BLANK

[ ] [A] blanks trace A.

SHIFT A' BLANK

[ ] [ ] blanks trace A'.

SHIFT

To recall a blanked trace on the CRT, press the VIEW key (e.g. [ ]).

B' VIEW

(9) If contents of trace A and trace B are desired to be exchanged under simultaneous four trace display preserving trace A' and trace B' as it is, it can be performed by the following operation.

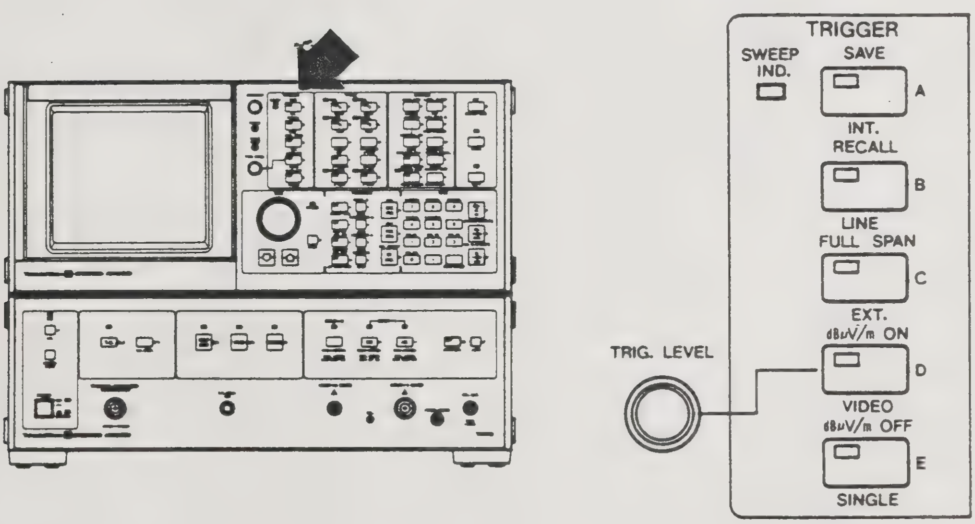
Specify taces A, A', B, and B' to VIEW mode, and then press [ ] , [ ] , [B] keys

SHIFT LABEL

Note that traces A and B, and traces A'and B' are ecxchanged simultaneously, if [ ] key is depressed.

A ⇄ B

4-11. TRIGGER



The analyzer sweep is triggered by selection of one of five modes.

(1) INT.

Automatically repeats internal triggering.

(2) LINE

Repeats triggering in synchronism with the line frequency.

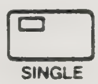
(3) EXT.

Allows the next sweep to start in synchronism with an external trigger signal (TTL compatible) supplied to the rear EXT. TRIG. connector. Triggering occurs at a HIGH to LOW transition of the external signal.

(4) VIDEO

Allows the next sweep to start if the detected IF envelope voltage rises to a level set by the TRIG. LEVEL knob. If the trigger fails, adjust the TRIG. LEVEL knob.

(5) SINGLE

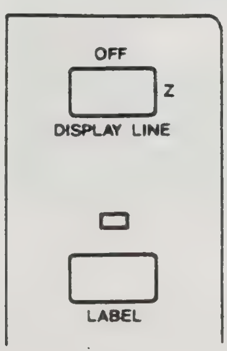


Allows the next sweep each time the SINGLE key is pressed.

(6) Trigger mode selection

One of the above five trigger modes should be selected. The indicator lamp on the selected key will light. Normally, set the trigger mode to INT.

4-12. DISPLAY LINE AND LABEL



4-12-1. DISPLAY LINE

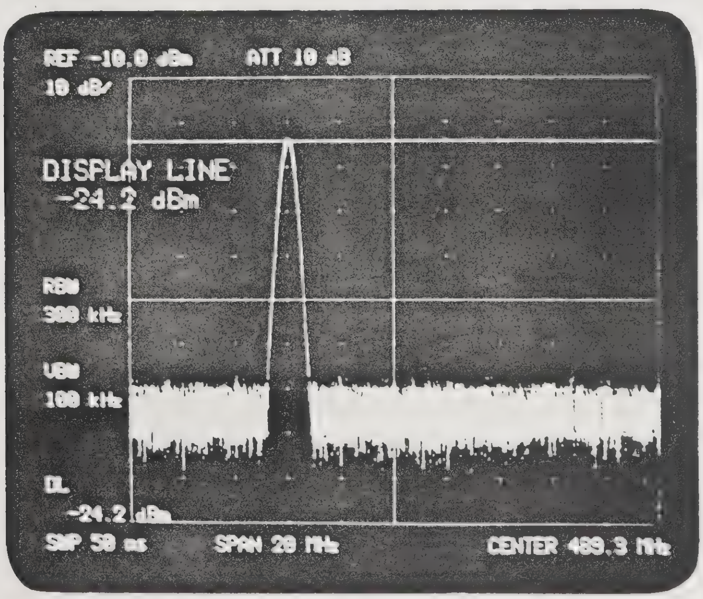
OFF
DISPLAY LINE

DISPLAY LINE activates a display line (horizontal cursor line) on the display.

The display line can be positioned anywhere within the graticule by the DATA knob or DATA step keys. The display line level is read to the left side of the CRT as "DISPLAY LINE XX dBm". The same readout is always presented at the bottom left corner of the display as "DL XX dBm". The peak level of a signal response trace can be easily read out by positioning the display line to that peak level.

The DATA step keys move the display line one tenth of the total amplitude scale per step. The DATA knob moves the line in display unit increments for finer control.

SHIFT OFF DISPLAY LINE erases the display line from the CRT display but does not reset the last position. If the display line is activated again with DISPLAY LINE, it will return to its last position.



4-12-2. LABEL

LABEL selects the LABEL entry mode; the indicator lamp just above the LABEL key lights, a cursor (-) appears on the CRT, and the front panel keys have functions different from those in the normal mode.

The LABEL mode permits entry of optional alphanumeric characters in the top area of the CRT display. The green letters presented beside each key are entered in this mode. Up to 54 characters can be entered per line. The DATA keyboard can be used for entry of numerical characters.

A space can be created between characters by pressing the ␣ (HOLD) key in the DATA section. If an entry error is made, press the BACK SPACE key on the DATA keyboard.

The last character will be erased and the cursor will backspace one character position.

When entry of a label is completed, press the SHIFT key. This will clear the LABEL entry mode and return the front panel keys to thier normal functions; the indicator lamp above the LABEL key goes off.

An entered label can be edited by deletion or insertion. For label editing, place the analyzer in the LABEL entry mode by pressing the LABEL key. The cursor position can be controlled with the DATA knob. To delete a label character, position the cursor to the character with the DATA knob and then press ⇩ once. To insert characters, position the cursor to the character location at which insertion begins and then press ⇧. A space of five consecutive character locations will appear at and beyond the cursor position. Each time a character is inserted into this space, the five character space moves to the right by one character location. When insertion is completed, press ⇧ again.

A character at the cursor position can be overwritten. The old character at the cursor position is overwritten with a new character.

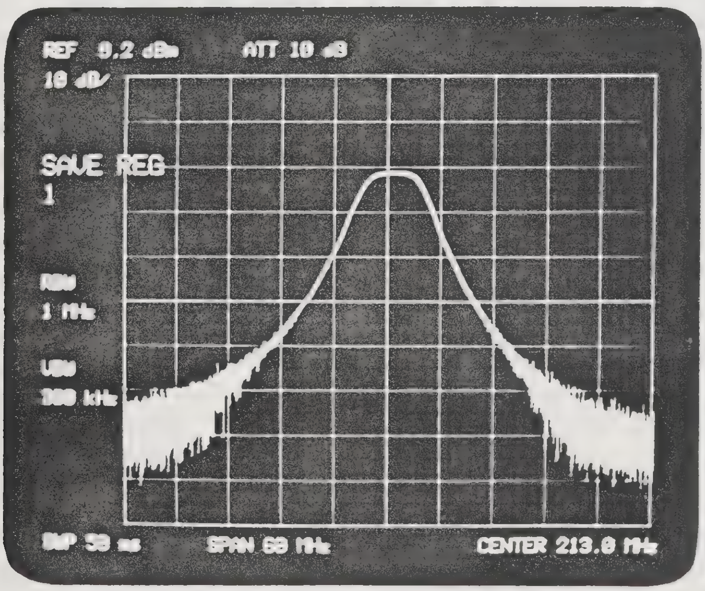
A character string entered in the LABEL mode can be cleared with SHIFT LABEL CLEAR ␣. It is also cleared when the MASTER RESET key is pressed or the device is switched to the STANDBY state.

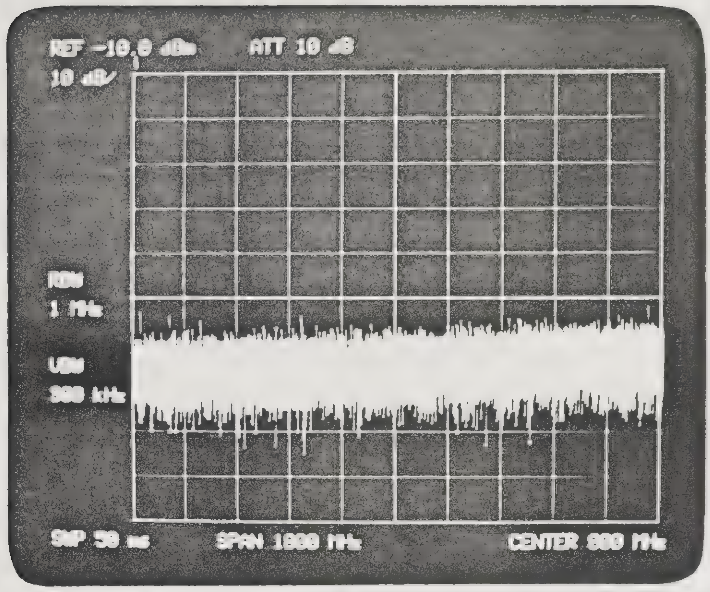
4-13. SAVE AND RECALL SAVE A RECALL B

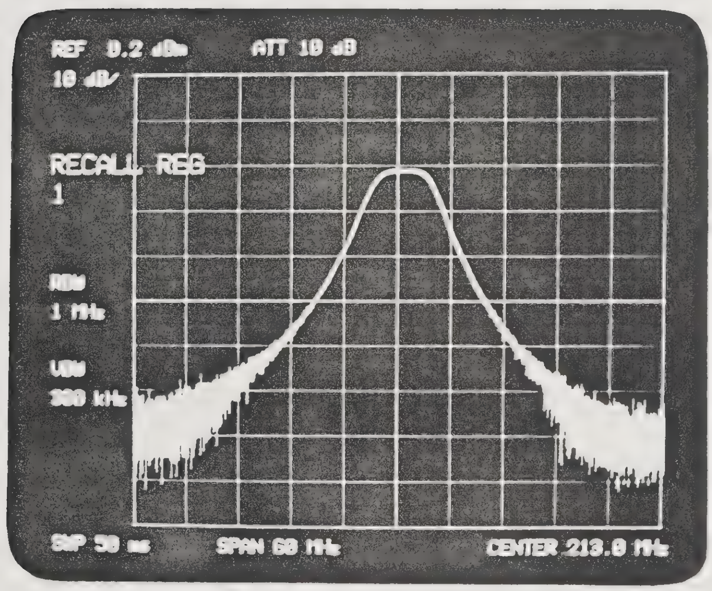
Up to 8 key statuses can be saved in internal registers and recalled as needed. To save the current key status press SHIFT SAVE, then press a numerical key between 1 and 8. The key status is saved in the register with the corresponding number. The saved key status can be recalled by pressing SHIFT RECALL and then the number key which corresponds to the register number from which the key status is to be recalled. When recalled, the current key status will be replaced with the saved key status.

The register contents remain intact even when the POWER switch is set to STANDBY. If the power cables of the instrument are unplugged from the outlets, the internal back-up battery maintains the register contents for about two weeks.

A label (character string entered in the top area of the CRT display) cannot be saved, nor can marker, trace, signal responses, or display line.







Save Registers 0 and 9 are also available as well as 1 through 8. However, the contents of Save Registers 0 and 9 may be changed when the MASTER RESET key is pressed, the power is turned off or the Error Correction Routine is executed or an optional function is executed.

4-14. SHIFT [SHIFT]

When the SHIFT key is activated, a key operated immediately after the SHIFT key provides supplemental or unique measurement capability indicated by yellow characters above each key. Some keys require the double shift operation for which the LABEL key must be pressed after the SHIFT key is operated, such as [SHIFT] [LABEL] [MHz dB sec].
This paragraph covers the description of the shift key functions hitherto not covered in the preceding paragraphs.

4-14-1. Video Averaging (AVG.)

In the Video Averaging mode, signal response data is averaged while it is weighted in the time domain. Averaged data are added to new data under a certain weight by the preset number (N). Averaging is effective only in the WRITE A mode.
The Video Averaging mode allows a good signal-to-noise ratio without long sweep time.
The Video averaging of each amplitude point on the frequency axis is given by the following equation:

$$yn = \frac{n - 1}{n} yn - 1 + \frac{1}{n} yn \quad (n \quad N)$$

where yn: n'th data
yn: n'th averaged data
yn - 1: (n - 1)th averaged data

To activate video averaging, press [SHIFT] [AVG. ON / VIDEO BW]; video averaging is immediately started.
The number of averaging is read to the top left corner of the display as "AVR XX", and the programmed number of averagings is read to the active function display area. (These readouts disappear when another function key is pressed.)
When the programmed number of averagings (N) is reached, $\frac{n - 1}{n}$ and $\frac{1}{n}$ in the above equation are fixed to $\frac{N - 1}{N}$ and $\frac{1}{N}$ respectively.

Averaging for $n > N$ is performed according to the following equation (however, the current averaging number readout on the display stops at $n = N$):

$$yn = \frac{N-1}{N}\,\overline{y}n - 1 + \frac{1}{N}\,yn$$

When the analyzer is initially switched on, the number of averagings is preset at 128. To modify this number, enter the desired number (2^n:64 for instance) from the DATA keyboard and then press one of the units keys. This technique allows programming of up to 4096 averagings. Averaging sequence temporarily stops and then restarts.

To disable averaging press [SHIFT] [AVG. OFF / CF STEP SIZE] m.

Do not change the analyzer's settings such as center frequency or frequency span while performing the video averaging. To change those settings, first stop the video averaging, then change those function settings, next restart the video averaging.

4-14-2. FULL SPAN (SHIFT C)

[SHIFT] [FULL SPAN] C sets center frequency to 900 MHz and frequency span to full 1800 MHz.

4-14-3. DETECTION (SHIFT n, p, s, z)

One of four detection techniques can be selected for displaying trace information.

(1) Normal Detection mode [SHIFT] [NORM. D.] n

The normal mode is initially selected when the analyzer is switched on. The positive and negative peak values are displayed alternately at each point on the frequency axis.

(2) Positive Peak Detection mode [SHIFT] [POSIT. PEAK D.] p

The positive peak detection mode displays signal maximums for the time period at each point on the frequency axis. "POS PK" is read in the active function display area.

(3) Negative Peak Detection mode [SHIFT] [NEG. PEAK D.]

The negative peak detection mode displays signal minimums for the time period. "NEG PK" is read in the active function display area.

(4) Sample Detection mode [SHIFT] [SAMPLE D.]

In the Sample Detection mode, the instantaneous signal value of the final analog-to-digital conversion for the time period is displayed. "SAMPLE" is read in the active function display area. When the Averaging mode is selected, the Sample Detection mode is automatically selected.

4-14-4. REF. OFFSET

Any desired offset value can be applied to the reference level of this unit. First press the [SHIFT] and [REF. LEVEL] (REF. OFFSET) keys, and then key in the offset value [XX dBm] using the DATA keyboard. If a negative unit offset value is required, press the [Hz −dBm μsec] switch after keying in the numerical value.

The input offset value is displayed constantly in the bottom left hand corner of the screen in the "OFFSET XX dB" format. Subsequent reference level, marker, and display line displays appear with this offset value added (or subtracted if a negative offset).

Offset input is still possible when the reference level is displayed in [dBμ]. In this case, press the [kHz +dBm msec] or [Hz −dBm μsec] switch after keying in the numerical offset value.

Reference level offset is cancelled and the offset value reset to zero by pressing the [SHIFT], [REF. LEVEL] (REF. OFFSET), [0], and [kHz +dBm msec] switches.

4-14-5. Electric Field Strength Measurement

(1) Connect an antenna to the TR4172 input terminal (50 Ω), noting that the antenna impedance must be 50 Ω. If not, achieve impedance matching by using a matching circuit.

(2) Set the center frequency and frequency span.

(3) Press [SHIFT] and [dBμV / FREQ. SPAN], to set the level unit to dBμ.

(4) Press the [MARKER] switch to obtain a marker output in the screen, and adjust the marker to the frequency spectrum to be measured.

(5) The relation between the marker point display level, that is, the TR4172 input terminal voltage ex (dBμV), and the actual electric field strength (dBμV/m), is given by the following expression.

$$Ex = ex + K$$

where K is an antenna coefficient (dB)

(6) When the Takeda Riken TR1722 half-wavelength dipole antenna is used, the above antenna coefficient K can be corrected for automatically.

Press [SHIFT] and [dBμV/m ON / VIDEO]. The marker unit is changed to dBμV/m, and the electric field strength Ex corrected for antenna coefficient K can be read directly. Note, however, that this calibration requires that the supplied 5D2W 10 m cable be used. Use of any other cable will result in the introduction of error.

(7) If the Takeda Riken TR1711 logarithmic periodic type antenna is used, press the [SHIFT] and [dBμV/m ON / VIDEO] keys. The Ex value will be a value obtained by subtracting 5 from the displayed value (in dBμV/m).

If [SHIFT], [REF. OFFSET / REF. LEVEL], [-5], and [Hz / -dBm / μsec] are pressed, an offset of -5 dBm is applied to the reference level. This means that the marker value can be read directly as the Ex (dBμV/m) value. In this case, too, calibration is dependent on the use of the 5D2W 10 m cable supplied. The use of any other cable results in the introduction of error.

(8) When [SHIFT] and [dBμV/m OFF / SINGLE] are pressed, the marker electric field strength measurement is cancelled, and the marker unit is made uniform with the reference level.

(9) If other antennas apart from TR1722 and TR1711 are used, calibrate with the following equation.

$$Ex = (ex + 6) + La - He + Ba$$
$$= ex + K$$

where He (dB) is the effective antenna length,
La (dB) is cable loss,
Ba (dB) is balun loss, and
K (dB) is the calibration coefficient.

The calibration coefficient for half-wavelength dipole antennas is determined from the following equation.

$$K = 20 \log \frac{\pi}{300} F + 6 + La + Ba$$

where F is the reception frequency (MHz)

$$= -33.6 + 20 \log F + La + Ba$$

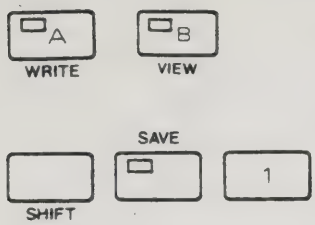
If a wide-band arithmetic periodic type antenna is used, subtract the antenna gain (half-wavelentgh dipole antenna ratio).

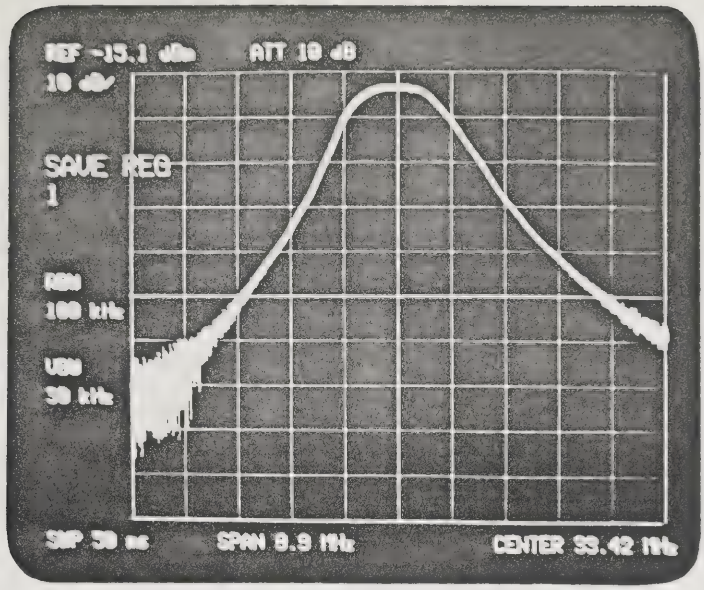
4-14-6. SAVE Register Alternate Sweep-1 SHIFT LABEL MHz dB sec

When SAVE registers 1 and 2, and WRITE A mode and WRITE B mode are used, measurement based on two independently set conditions can be executed alternately, and the results of both measurements can be displayed simultaneously in the screen. The procedure involved is described below. In the examples shown here, the vertical axis scale is set to 10 dB/div. and 2 dB/div.

(1) With the instrument in the initialized state, press the B VIEW switch to select WRITE A VIEW B mode where the first measuring condition is set. The vertical axis scale in the initialized state is 10 dB/div.
Set the center frequency and the frequency span.

(2) Press SHIFT, SAVE, and 1 to store the first measuring condition in SAVE register 1.

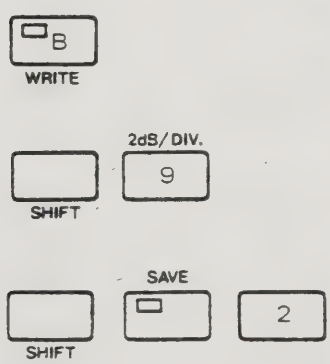


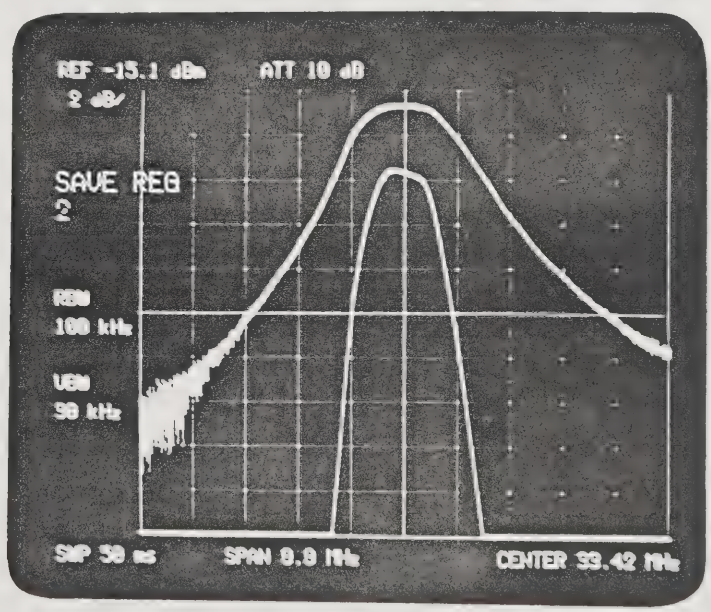


(3) Then press the B WRITE switch to select WRITE B VIEW A mode. The vertical axis memory is changed to 2 dB/div. by pressing SHIFT and 2dB/DIV. 9.

(4) Although other measuring conditions can be varied as desired, do not change CENT. FREQ or FREQ. SPAN. If change to either of these functions is desired, refer to the following Save register alternate sweep - 2 procedure.

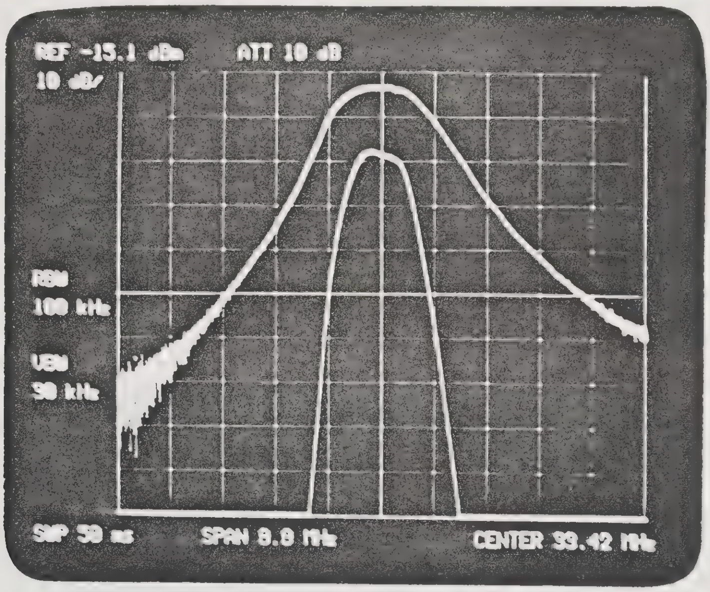
(5) Press SHIFT, SAVE, and 2 to store the second measuring condition in Save register 2.





(6) The alternate sweep mode is selected by pressing [SHIFT], [LABEL], and [MHz dB sec]. SAVE register 1 [A WRITE] and SAVE register 2 [B WRITE] are recalled alternately at each sweep, and are displayed simultaneously in the screen.
The LED Indicator lamps in the [A WRITE] and [B WRITE] switches come on alternately to indicate the alternate sweep mode.
If a short sweep time is selected, the readouts may be difficult to read because they change at a relatively high rate.
The Alternate sweep mode can be disabled by pressing any key.

[SHIFT] [LABEL] [MHz dB sec]



4-14-7. SAVE Register Alternate Sweep-2 [SHIFT] [LABEL] [kHz +dBm msec]

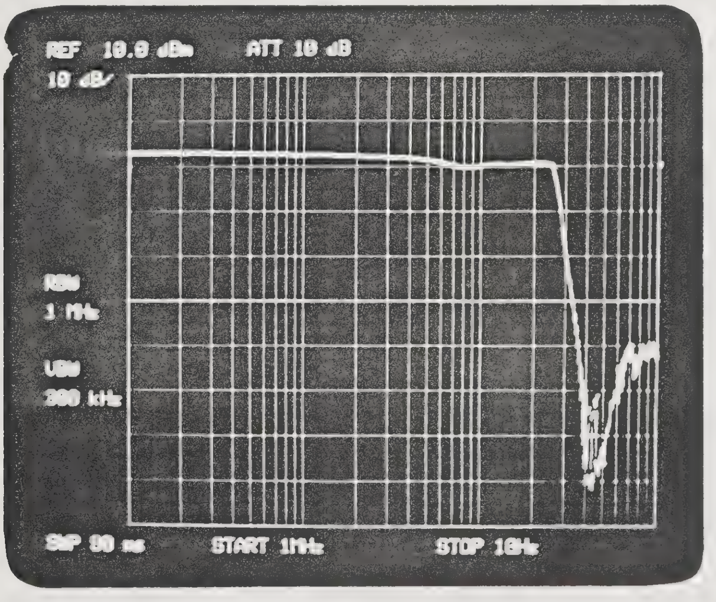
In addition to the functions saved in the SAVE register alternate sweep-1 mode, different center frequency and frequency span data can be saved in SAVE registers 1 and 2 in the SAVE register alternate sweep-2 mode. The required save method is identical to that for the SAVE register alternate sweep-1 mode. In the alternate sweep-2 mode, the display writing rate may be lower than that in the alternate sweep-1 mode.

4-14-8. Logarithmic Scaling for Frequency (Log Display)

After blanking the B and B' traces, pressing [SHIFT] [LABEL] [CENT. FREQ.] places the horizontal graticule in the logarithmic scale. The center frequency and frequency span readouts disappear from the display and, instead, a START frequency (frequency at the left most graticule) and a STOP frequency (frequency at the right most graticule) are read out. The START frequency is selected from 100 Hz, 1 kHz, 10 kHz, 100 kHz, and 1 MHz so that the center frequency on the linear scale is positioned near to the center of the display. Since the frequency span covers three decades, a STOP frequency is 1000 times as large as a START frequency. For instance, when the center frequency is between 100 kHz and 900 kHz, the START and STOP frequencies are 10 kHz and 10 MHz respectively.

The analyzer can be returned to the linear mode by operating any key except the [- - - -] key for plotting. (See page 8-25 for plotting.)

A log display example is given below.



When observing noise wavefrom, press [SHIFT] [SAMPLE D.]^z to select the sample detection mode before entering the log. display mode. When the RES. BW. key is in the AUTO mode, a constant resolution bandwidth may not be selected over the three decades. To obtain a constant resolution bandwidth over the three decades, press the RES. BW. key to select MANUAL mode and select desired resolution bandwidth in MANUAL mode before entering log. display mode.

Logarithmic scaling trace in memory A can be stored by operating keys [B VIEW] [A ⇄ B] . If the HOLD key is presssed to return to linear scale mode, information of logarithmic scaling trace except vertical graticule stored in memory B is saved. Press the key Q when plotting by TR9834R is desired.

4-14-9. Error Correction Routine

Absolute level errors due to resolution bandwidth switching can be corrected using the TR4172 calibration signal. After warming up the instrument for more than one hour, mount the supplied N-BNC adapter on the INPUT-1 connector, then connect the CAL. OUT. connector to INPUT-1 connector with the supplied input cable MC-61.

Press [SHIFT] [LABEL] [ ]^W to enter the error correction routine.

Execution of the routine will continue for approximately one minute, during which "CALIBRATING" message is shown in the left informaion area on the display and all the control key functions on the front panel of the TR4172 are disabled.

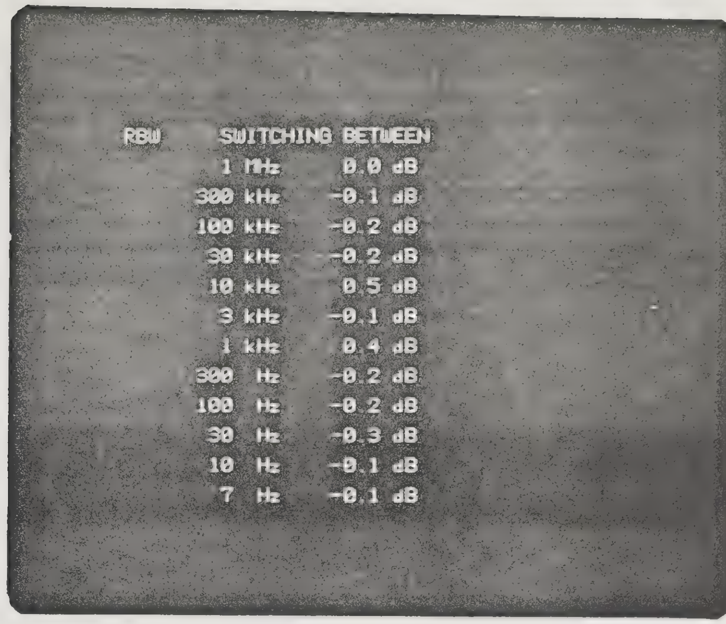
When executin of the error correction routine is completed, dispaly errors for the -20 dBm CAL. signal at each resolution bandwidth setting are stored in internal memory. For all the subsequent measurements, the reference level is automatically corrected according to the stored error information. The error information stored in memory can be listed on the display by operating [SHIFT] [LABEL] [ ]^X . Check if all error levels are within ±3 dB. After checking the listing, press any key to restore the normal display

image. If there is any error level which exceeds ±3 dB, adjust the CAL. control on the front panel. The CAL. control adjusts IF gain of the instrument; clockwise rotation decreases the gain (and hence the level on the display), while counterclockwise rotation increases it. If the level error exceeds +3 dB, turn the CAL. control clockwise; if it is below -3 dB, turn the control counterclockwise.
After the adjustment using the CAL. control is completed, execute the error correction routine again and list the level error information on the diaplsy. Make sure that all level errors are now within ±3 dB. Error information stored in the memory will remain intact even if the MASTER RESET key is pressed, POWER switch is set to STANDBY, or the power cable is unplugged from its supply outlet. The internal back-up battery (Ni-Cd) maintains the information against power off for up to two weeks.

To clear the error information from the memory, press [SHIFT] [LABEL] [BACK SPACE] . If an error correction routine is executed subsequent to a previous one, the previous error information is replaced with the new error information.
If the error correction routine is executed with the CAL. OUT. connector disconnected from the INPUT-1 connector, the following message will be shown in the left information area on the display:

PLEASE CONNECT CAL. OUT. TO INPUT-1
CONTINUE OR QUIT? 0 OR 1

When executing the error correction routine, connect the CAL. OUT. connector to INUT-1 with the MC-61 cable, then press key 0 on the numeric data keyboard. To suspend the execution press key 1 on the numeric keyboard.



4-15. QP Measurement Mode (Option 01)

4-15-1. Outline

Option 01 is used to measure impulsive noise. As indicated in Table 4-2, the various constants used in the measurement comply with the values prescribed by CISPR standards.

Table 4-2 CISPR standards concerning basic QP measurement characteristics

	Frequency range	6 dB BW	Charging time constant	Discharging time constant	Mechanical time constant
A	10 kHz to 150 kHz	200 Hz	45 ms	500 ms	160 ms
B	150 kHz to 30 MHz	9 kHz	1 ms	160 ms	160 ms
C	30 MHz to 300 MHz	120 kHz	1 ms	550 ms	160 ms
D	300 MHz to 1 GHz	120 kHz	1 ms	550 ms	160 ms

4-15-2. QP value measurement

(1) Set the center frequency and the desired frequency span.

(2) Press  INPUT ATT. and increase or decrease input attenuation with the DATA knob or step keys, 10 dB at a time, while observing the waveform on display.

(3) Check that the waveform level does not vary. If it varies, input to the TR4172 is saturated. To avoid saturation, increase input attenuation or insert a bandpass filter or equivalent in the input circuit.

(4) If no variations in the waveform level have been verified, change the reference level with [REF. LEVEL] to set the output peak level 20 dB to 30 dB down from the top of the screen before entering a QP measurement mode listed in Table 4-3.

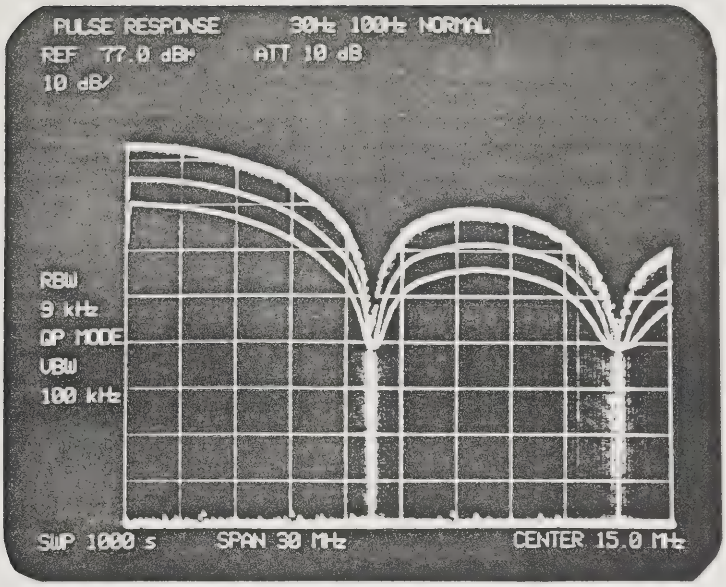
Table 4-3 QP measurement modes

Frequency range		6 dB BW	QP measurement
A	10 kHz to 150 kHz	200 Hz	[SHIFT] [LABEL] [ ] j
B	150 kHz to 30 MHz	9 kHz	[SHIFT] [LABEL] [ ] k
C,D	30 MHz to 1 GHz	120 kHz	[SHIFT] [LABEL] [ ] m
To cancel QP measurement mode,			[SHIFT] [LABEL] [ ] z

(5) QP measurement involves the use of long time-constant circuits as shown in Table 4-2, requiring sufficiently long sweep time settings. As a general rule, set a sweep time of 1 second/200 Hz in frequency range A (10 kHz to 150 kHz), to 1 second/10 kHz in frequency range B (150 kHz to 300 MHz), and to 1 second/100 kHz in frequency ranges C and D (30 MHz to 1 GHz).

For example, the sweep time should be set to 50 seconds if measuring in a frequency range with a frequency span of 10 kHz.

(6) After setting the sweep time, press the MARKER switch to output a marker. The level at the marker point is represented in dBμ, indicating the QP value of the input terminal at the marker-point frequency.



(7) Press [SHIFT] , [dBµV/m ON] when a Takeda Riken TR1722 half-wavelength dipole antenna is used.
This key-in sequence automatically corrects the antenna coefficient to represent the marker point level in dBµV/m, permitting the QP value to be read directly.

(8) With a Takeda Riken TR1711 logarithmic-period antenna, press [SHIFT] [dBµV/m ON] [SHIFT] [REF. OFFSET / REF. LEVEL] [5] [Hz / −dBm / µsec] to enter an offset of −5 dB in the reference level.
Again, the antenna coefficient is automatically corrected, enabling direct reading of the QP value. (It is displayed in dBµ.)

(9) The automatic correction for the TR1722 and TR1711 antennas assumes the use of the supplied 10m 5D2W cable.
Use of any other cable might produce an error in antenna coefficient correction.

(10) If a different antenna is used, calculate the QP value by determining the correction coefficient with reference to 4-14-5. "Electric field strength measurement."

(11) To cancel the QP measurement mode, press [SHIFT] [LABEL] [AUTO] z.

4-15-3. QP BW Check

6 dB BW (bandwidth) of CISPR standards listed in Table 4-2 can be verified by following the procedures given below.

(1) Connect the CAL. OUT signal to the INPUT-1 connector of RF section, and set the center frequency to 50 MHz by operating keys [CENT. FREQ.] [5] [0] [MHz dB sec] .

(2) Set the frequency span, depending on which of frequency ranges A to D has been set, as indicated in Table 4-4.

Table 4-4 QP BW check

Frequency range		6dB BW	Frequency span	QP BW check mode
A	10 kHz to 150 kHz	200 Hz	2 kHz	[SHIFT] [LABEL] [M]
B	150 kHz to 30 MHz	9 kHz	10 kHz	[SHIFT] [LABEL] [N]
C, D	30 MHz to 1 GHz	120 kHz	1 MHz	[SHIFT] [LABEL] [O]
To cancel QP BW check mode, [SHIFT] [LABEL] [AUTO Z]				

After entering the frequency span, execute one of the QP BW check modes, depending on which of frequency ranges A to D has been set, as indicated in Table 4-4.

(3) Freeze the spectrum by pressing [A VIEW] key, and then press [⊿] key and use the DATA knob to check 6 dB bandwidth.
Specifications are as shown below.
A) 200 Hz ± 20 Hz
B) 9 kHz ± 1 kHz
C, D) 120 kHz ± 20 kHz

4-16. X-Y RECORDER OUTPUT (OPTION 03)

This optional output provides signal response and graticule information (display line and markers are not included) to an X-Y recorder. The information on the display is subject to digital-to-analog conversion and coupled to the X, Y, and Z connectors on the rear of the instrument in the form of analog signals. The usage of this optional output is explained in the following:

First, connect the TR4172's rear X, Y, and Z connectors to the X, Y, and Z inputs on the X-Y recorder respectively.

Each output has an output voltage range of 0 V to approximately +5 V. The Z output provides pen up/down control: 0 V for pen up, and approximately +5 V for pen down. While the initial default setting for the Z output for pen lift control is 0 V for pen up and approximately +5 V for pen down, this condition can be reversed by key operation (See page 4 - 67). If the Z output does not match the specification of the X-Y recorder used, use the Pen Lift switch on the recorder for pen up/down control.

The necessary key operations for the optional output are described below:

(1) X-Y recorder output mode

Press [SHIFT] [LABEL] [2] to select the X-Y recorder output mode. Message "X-Y RECORDER" will be shown in the active function display area of the screen. In this mode each front panel key has functions different from those used for normal measurement. To clear the X-Y recorder mode, press the SHIFT key.

(2) Setting the image size and position

To set up the size and position of the output image on the X-Y recorder, press the [⇩] key. This will lift the recorder's pen and move it to the lower left home position. Message "LOWER LEFT" will be shown in the active function display area of the screen. Operation of the [⇧] key lifts the pen and moves it to the upper right home position. Message "UPPER RIGHT" will be shown in the

active function display area of the screen.
Determine the size and position of the output image on the recorder by adjusting the gain and offset of the recorder while operating these two keys.

(3) All trace and scale output

Operation of the A WRITE key causes the X-Y recorder to record all traces (traces A, A', B and B') and graticule. After recording one trace, the recorder's pen lifts, returns to the lower left home position, and then starts recording the next trace or graticule. If the Z output (pen lift signal) of the TR4172 does not match the X-Y recorder specification, pen lift operation will not be done automatically. In this case, use (4) through (8) below, and manually lift the pen at the end of each trace output, press the  key to return the pen to the lower left home position, then lower the pen again before starting output of another trace or graticule.

(4) Output of only the graticule

Press the B WRITE key to output only the graticule.

(5) Trace A output

Press the A VIEW key to output trace A.

(6) Trace B output

Press the B VIEW key to output trace B.

(7) Trace A' output

Press the A' VIEW key to output trace A'.

(8) Trace B' output

Press the B' VIEW key to output trace B'.

(9) Holding recorder operation

If the HOLD key is pressed, the X-Y recorder temporarily suspends

its operation with its pen lifted up. A second operation of the HOLD key restarts recorder operation from the hold point. If other trace key (e.g. A WRITE key) is pressed when the pen remains stationary, the pen will automatically return to the lower left home position and then start output of the trace selected with the trace key.

(10) Clearing the X-Y recorder output mode

To clear the X-Y recorder output mode, press the SHIFT key.

(11) Recording speed selection

The frequency axis of the TR4172 usually consists of 1001 data points. Each of these points is subject to digital-to-analog conversion at approximately 100 ms sampling rate for the optional X-Y recorder output. This sampling rate can be varied between approximately 10 ms and 1000 ms with the SWEEP TIME key and DATA knob used together.

Operation of the SWEEP TIME key will show the current sampling rate "100 ms/POINT" in the active function display area of the screen. Use the DATA knob to change this active readout of sampling rate to the desired rate.

This newly specified sampling rate will be cleared into 100 ms/POINT and its readout will disappear from the active function display area when the X-Y recorder output mode is cleared with the SHIFT key operation.

(12) Pen up/down control setting

If the Z output of the TR4172 properly matches the pen control input of the attached X-Y recorder, operation of RES. BW i key will lift the pen, and operaiton of AUTO p will lower it. If the actual pen movement is the reverse of the above, reverse the polarity of the Z output according to the following instructions:

(13) Z ouput polarity reversal

If VIDEO BW k key is pressed, the Z output provides 0.0 V for pen-up and approximately +0.5 V for pen-down. At this time the message

"PEN UP/DOWN = LO/HI" is shown in the left information area on the display.

If AUTO key is pressed, the Z output provides approximately +5.0 V for pen-up and 0.0 V for pen-down. At this time the "PEN UP /DOWN = HI/LO" is shown in the left informatuon area on the display.

4-17. WRITING UPPER AND LOWER LIMIT DATA

Upper and lower limit data can be written on the TR4172's screen directly from its front panel. This allows the operator to know whether the signal response trace in question falls within the limits or not at a glance (see Figure 4-1).

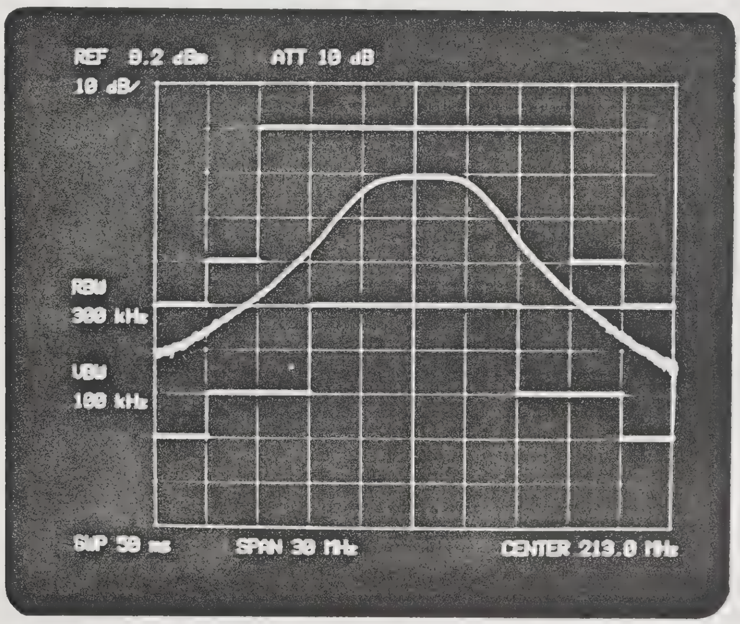


Fig. 4-1 Signal response observation with upper and lower limit data written on the screen

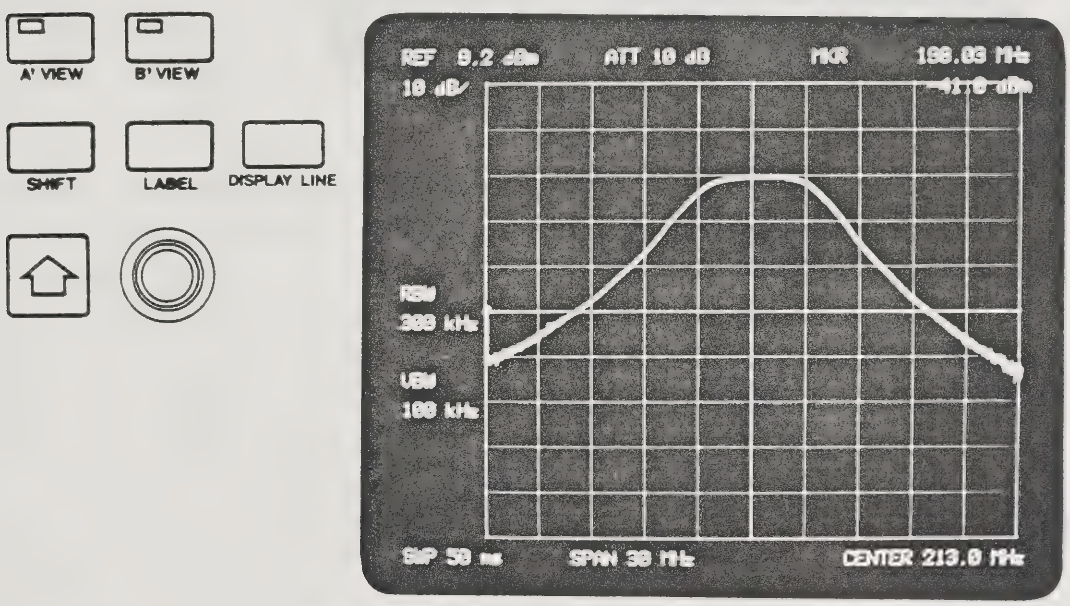
First write upper (or lower) limit data into memory A, then transfer the data to memory A'. Next, write lower (or upper) limit data into memory A, then place the analyzer in WRITE B mode for signal observation. More detailed procedure is described in the following:

(1) Press the VIEW A key. Place memory B into VIEW B or BLANK B mode.

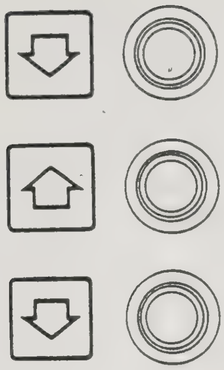
(2) Press [SHIFT] [LABEL] [DISPLAY LINE] keys. This will present an active marker at the bottom left corner of the screen.

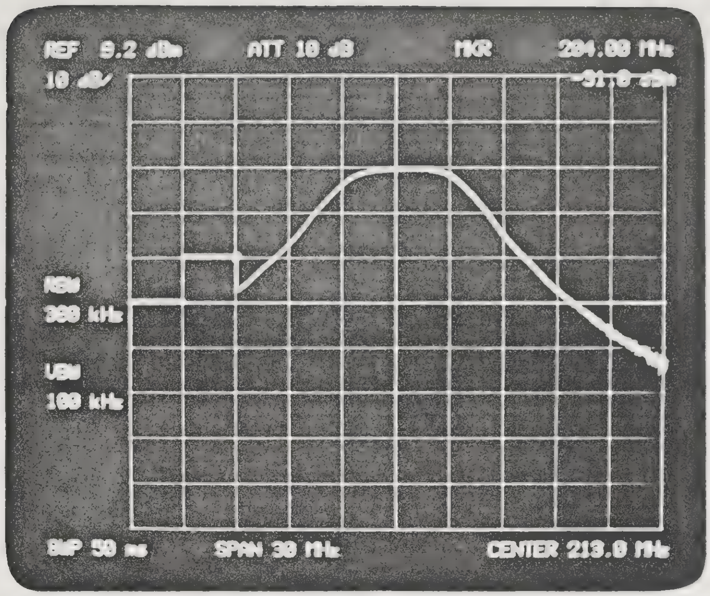
(3) Operation of [⇧] or [⇩] key will enter the upper or lower limit data write mode.

(4) If [⇧] key is pressed, rotation of the DATA knob moves the marker in the vertical direction: clockwise operation of the knob moves the marker upward, and counterclockwise operation of the knob moves it downward.



(5) If [⇩] key is pressed, operation of the DATA knob moves the marker in the horizontal direction to enable upper or lower limit data writing. Subsequently use [⇧] or [⇩] key to write the desired upper (or lower) limit data on the screen.





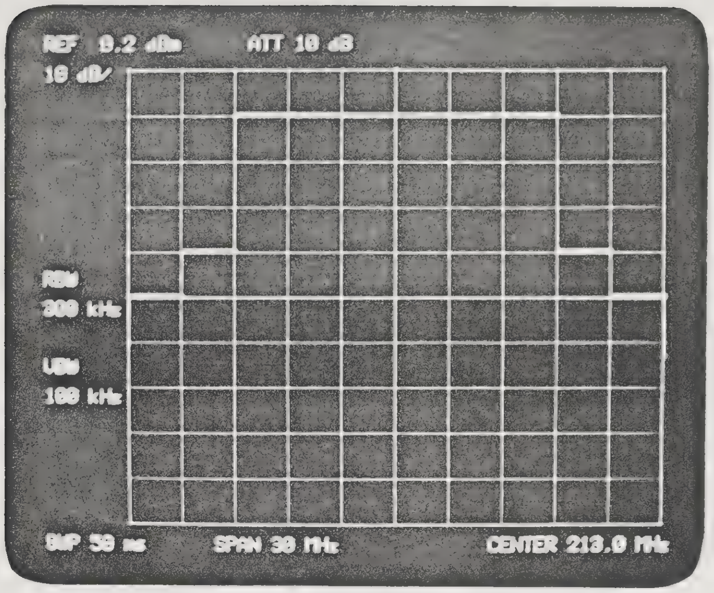
(6) While upper or lower limit data is being written, the frequency and level at the marker are read out at the top right corner of the screen.

(7) If the DATA knob is operated after BACK SPACE key is pressed, limit data writing will not occur, and the marker simply moves along the upper or lower limit trace already written on the screen.

Operation of or key will again enter the limit data write mode.

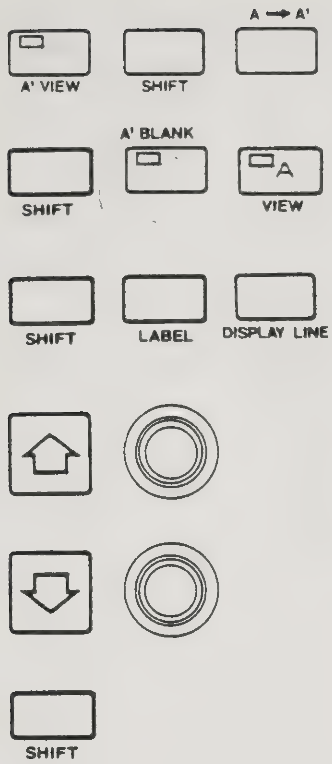
(8) When all upper (or lower) limit data is written, press the SHIFT key. This will erase the marker from the screen and place the analyzer into the normal measurement mode.

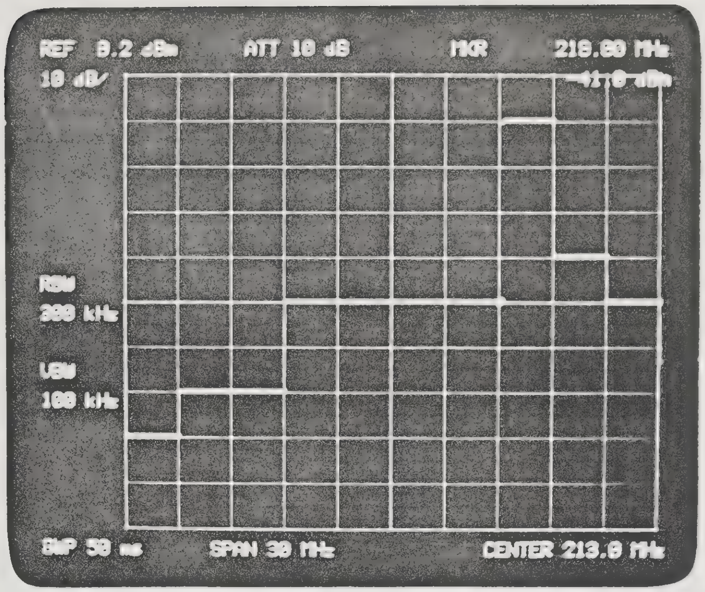
SHIFT



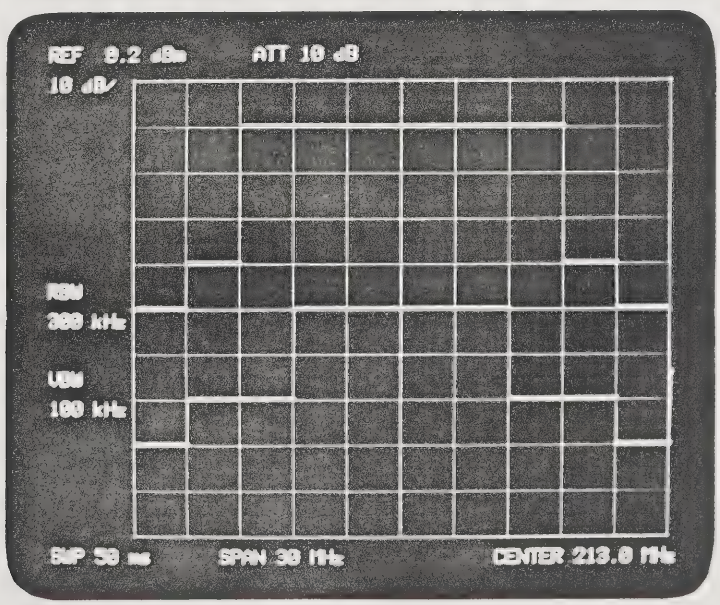
(9) When subsequently writing lower (or upper) limit data as well, proceed with following steps (10) and (11). If not, proceed with step (12).

(10) When writing lower (or upper) limit data following upper (or lower) limit data writing, press A' VIEW, SHIFT, A → A', SHIFT, A' BLANK and A VIEW keys, then press SHIFT LABEL and DISPLAY LINE key to present and active marker. Then follow the procedure given in above steps (3) through (7) to write lower (or upper) limit data directly on the screen.

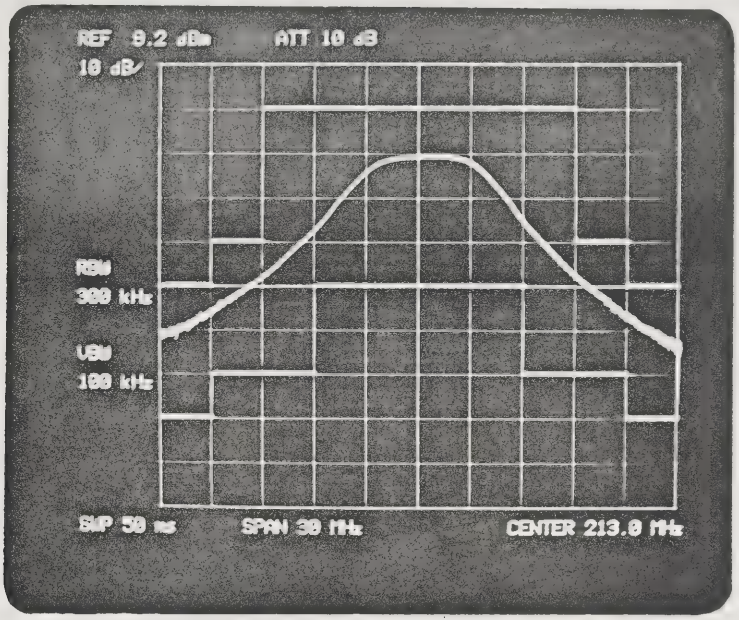


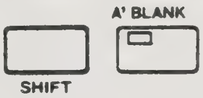


(11) When all lower (or upper) limit data is written into memory A, press the SHIFT key to erase the marker from the screen, then press the VIEW A' key. This will show the lower and upper limit traces each stored in memories A and A', on the display.



(12) Press the WRITE B key and observe the signal response of the DUT.



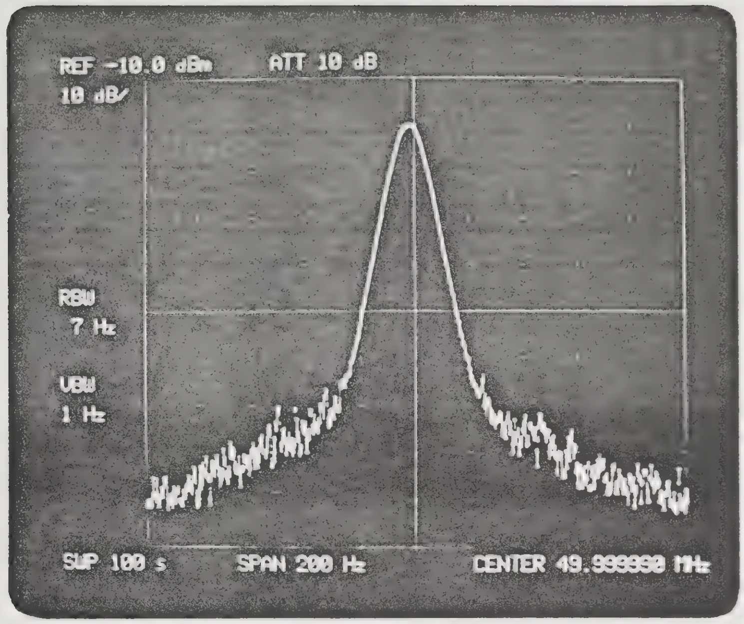
(13) Operation of the WRITE A key erases the lower (or upper) limit data from memory A. Operation of  keys erases the upper (or lower) limit data from display, but memory content remains. Therefore, operation of VIEW A' key displays the upper (or lower) limit again.

4-18. SWEEP RESET

Operation of  keys resets sweep to cause it to restart from the leftmost graticule.

4-19. RES. BW 7 Hz

Operation of  keys sets resolution bandwidth (RES. BW) to 7 Hz. In this case, however, data will not be guaranteed as the bandwidth accuracy is outside the specification.



4-20. CENTER FREQUENCY REPOSITIONING (DRIFT CANCEL)

(1) On the TR4172, center frequency is repositioned for each sweep when the following center frequency and frequency span are selected, so as to prevent frequency drift:
Center frequency: 1500 MHz or below and
Frequency span: 10 MHz to 510 kHz, or 10 kHz or below

(2) To clear the center frequency repositioning mode for faster screen rewriting, press SHIFT LABEL 5 keys. Center frequency repositioning will subsequently not occur (Drift cancel OFF). The center frequency repositioning mode will be restored by operating SHIFT LABEL 4 keys or MASTER RESET key. (Drift cancel ON)

(3) If the center frequency repositioning mode is desired for a center frequency and frequency span other than those given above, operate SHIFT LABEL 4 keys. The center frequency will be repositioned for each sweep. If, at this time, the CENT. FREQ., FREQ. SPAN, or MASTER RESET key is pressed, the analyzer returns into the original center-frequency repositioning mode, in which center frequency repositioning occurs only for the center frequency and frequency span ranges specified in above item 1.

4-21. OCCUPIED BANDWIDTH DISPLAY (OPTION)

This option performs necessary operations to determine the occupied bandwidth from the displayed data on the TR4172. The operations are performed as follows:

There are 1001 points of data on the frequency axis of the TR4172's display. If the voltage of one of the points is assumed to be Vn, the total power P of the signal response on the display is determined by:

$$P = \sum_{n=1}^{1001} \frac{Vn^2}{R} \qquad \text{(R: TR4172's input impedance)}$$

If the sum of the power between the first (leftmost) and X'th points on the frequency axis is 0.5% of P, then we obtain:

$$0.005P = \sum_{n=1}^{X} \frac{Vn^2}{R}$$

If the sum of the power between the first (leftmost) and Y'th points on the frequency axis is 99.5% of P, we obtain:

$$0.995P = \sum_{n=1}^{Y} \frac{Vn^2}{R}$$

We determine X and Y from the above three equations, then determine the occupied bandwidth (OBW) from the following equation along with frequency span f_{SPAN}:

$$OBW = \frac{f_{SPAN}(Y - X)}{1001}$$

The OBW display procedure is described below.

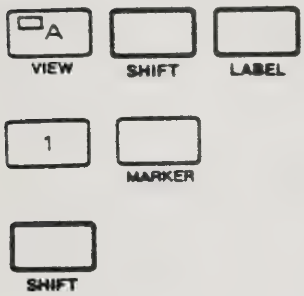
(1) Select the WRITE A mode and display the desired signal response trace in the center of the screen. Set the vertical scale to 10 dB/div. and leave all marker inactive.

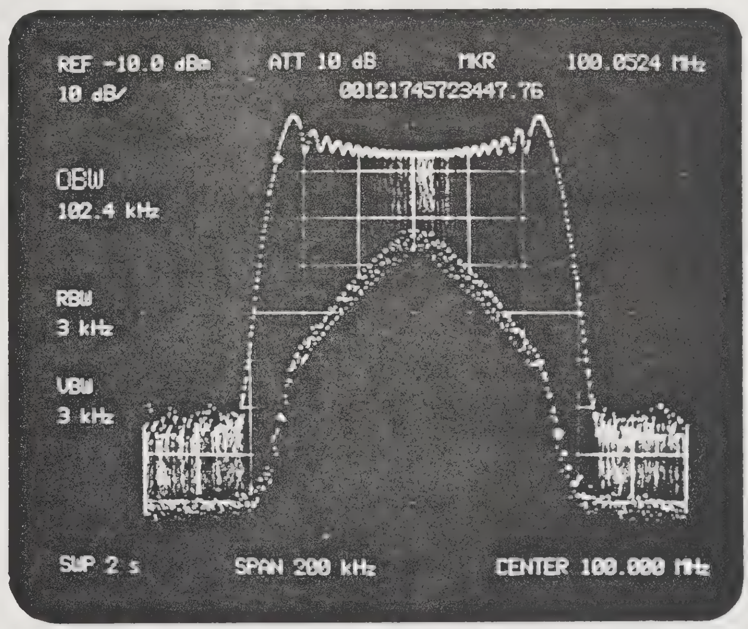
(2) Press the VIEW A key to hold the display, then press [SHIFT] [LABEL] [1]. The occupied bandwidth operation will be initiated. Upon the end of the operation, two markers will appear at points X and Y mentioned above to indicate the calculated occupied bandwidth.

(3) Operation of the MARKER key will display the occupied bandwidth readout at the top left corner of the screen together with indicator "OBW". The marker frequency readout at the top right corner of the display shows the frequency at the right-hand side marker.

(4) To obtain the relative value readout of the total spectrum power, P (1×10^3 to 1.7×10^{13}), in the top display area of the screen, press the SHIFT key.

(5) If the MKR OFF key is pressed, the display and readouts pertaining to occupied bandwidth disappear from the display and the TR4172 returns to the normal measurement mode.





(6) Occupied bandwidth data can be obtained with less error by setting resolution bandwidth to 1/200 of the frequency span or less. And maximum value or average value of the occupied bandwidth can also be measured by using MAX. or AVG. mode concurrently.

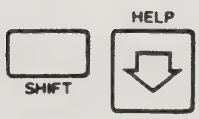
4-22. HELP MODE

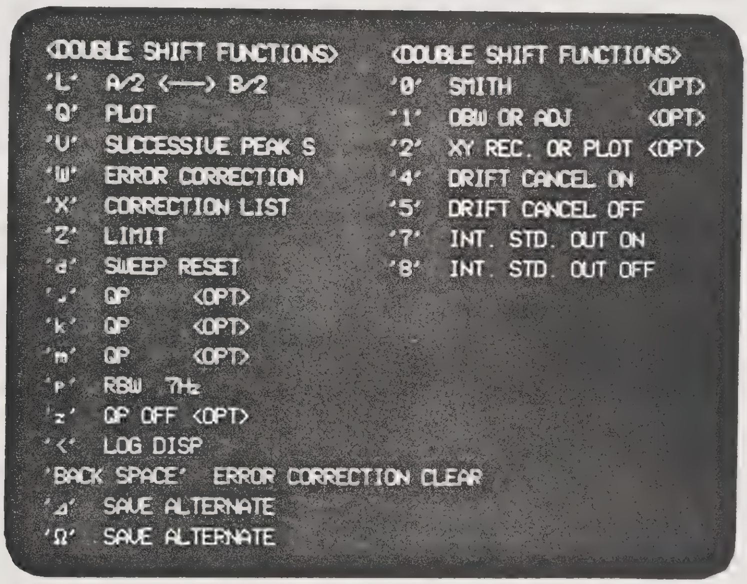
No specific panel inscription or indicator is provided for the double shift function for which a specific key is pressed after SHIFT and LABEL keys are operated.

Operation of SHIFT HELP ⇩ selects the HELP mode, in which the display provides a listing of the above double shift key functions on the screen.

Note that when the instrument is set up in the state in which only the specific key operation can be entered in the mode such as ALTERNATE SWEEP or LOG. DISPLAY, the HELP mode cannot be activated.

Reset the mode to the normal measurement mode to activate the HELP mode.





Pressing HOLD µ or BACK SPACE key clears the list and the analyzer returns to the normal condition.

Appendix A-1 lists the pages containing descriptions of each double shift function.

Appendix A-1 lists the pages containing descriptions of each double shift function.

4-23. MEASURING ADJACENT NOISE LEVEL OF OSCILLATION BY AVERAGING

This paragraph describes how to measure the adjacent noise level for 50 MHz oscillation by using the averaging feature (p4-52). The adjacent noise analysis range is assumed to be ±50 kHz of the oscillation frequency.

(1) Connect the output of a 50 MHz oscillator to INPUT-1 on the TR4172 as shown in Figure 4-1.

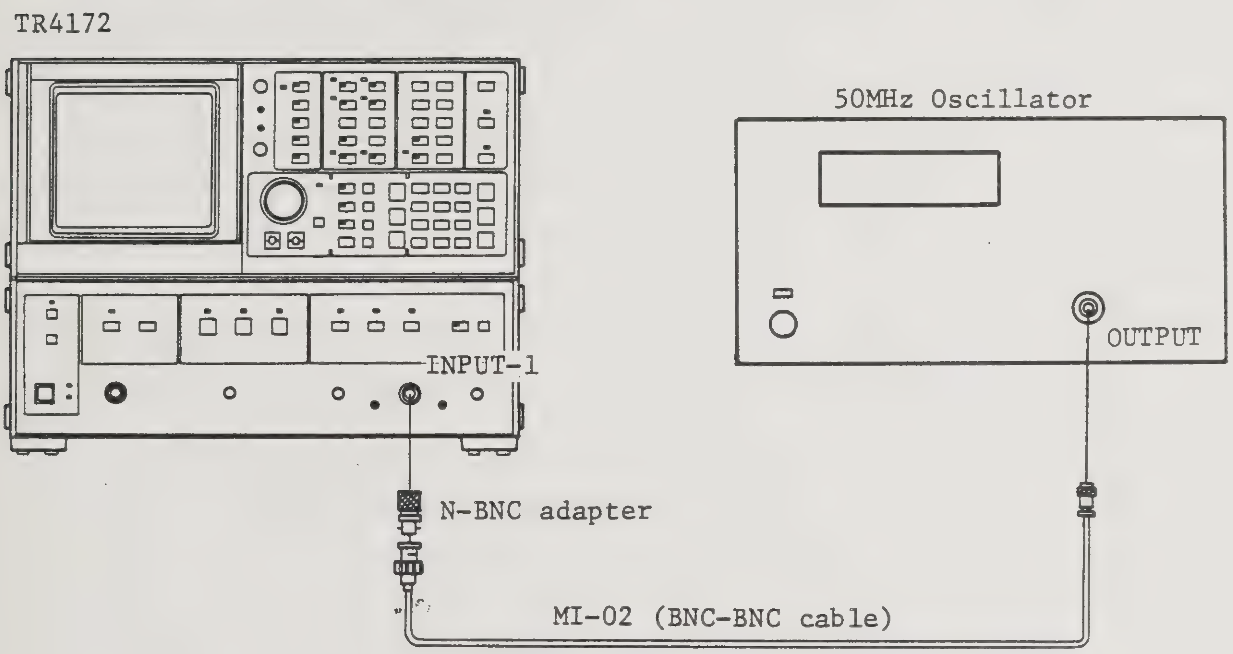


Fig. 4-1 Measurement setup

NOTE

1) When the oscillator output is directly coupled to the TR4172 input, the output frequency may be subject to change due to the input capacitance of the TR4172. If this occurs, use a probe with a smaller cable capacitance for the input connection.

2) The maximum allowable input level to the TR4172 is +20 dBm when the input attenuator is set at 20 dB or greater.
Be careful not to apply an input level exceeding +20 dBm. Use an external attenuator if necessary.

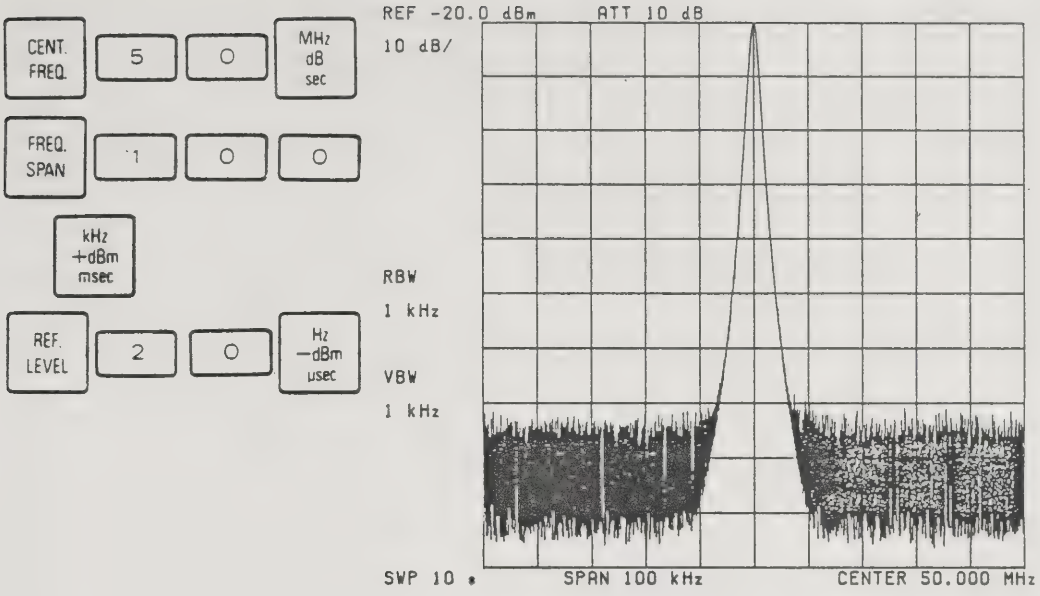
(2) While the TR4172 is in the initial default state (immediately after MASTER RESET key operation), prepare it as follows:

(a) Set the center frequency to 50 MHz.

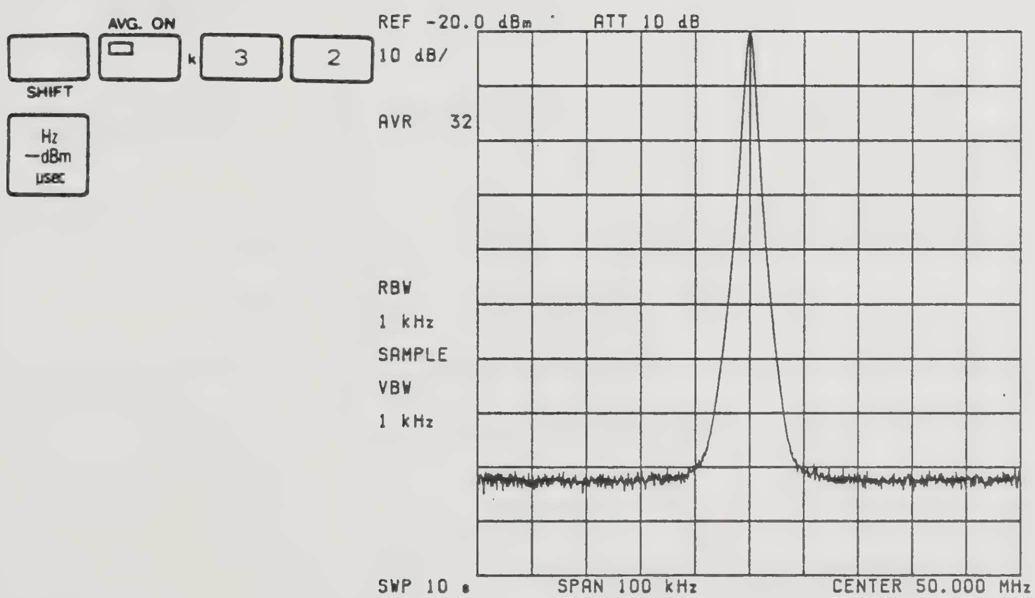
(b) Set the center frequency span to 100 kHz to accommodate the analysis range of ± 50 kHz.

(c) Set the reference level. For example, if the input signal level is -20 dBm, set the reference level to -20 dBm.

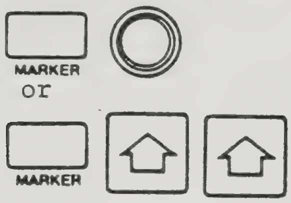
(d) The sweep span, resolution bandwidth, video bandwidth, and so forth are automatically set to the optimum values according to the selected frequency span, since the AUTO mode is in the initial default selection. If, for example, desire manual selection for those parameters, press [RES. BW] [1] [kHz +dBm msec] to set resolution bandwidth to 1 kHz. Once the manual mode is selected for a parameter, the lamp in the relevant parameter key comes, on. In this case, the resolution bandwidth is fixed to 1 kHz. Note that the resolution bandwidth remains at 1 kHz if the frequency span is subsequently changed.

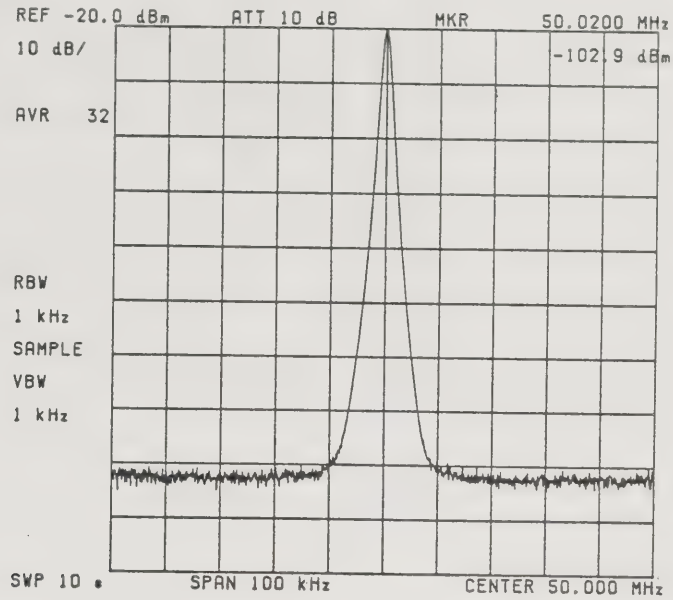


(3) Repeat averaging 32 times



(4) Activate a marker and measure the adjacent noise level (for example 20 kHz apart from the signal response).





The marker will move one horizontal division on the scale each time the stop key is pressed. In this example, operating the step key twice.

PEAK SEARCH captures the maximum peak of the displayed signal response trace.

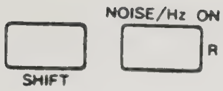
MKR → REF. positions the reference level at the level identified by the marker (disabled during averaging).

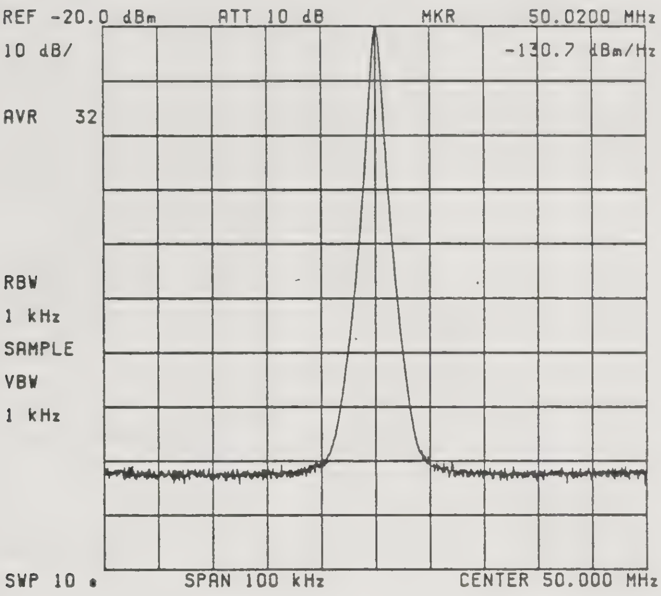
MKR → CF specifies the frequency identified by the marker as the center frequency (disabled during averaging.)

SHIFT NEG. PEAK S. captures the minimum level of the displayed signal response trace.

(5) If you wish to measure adjacent noise level (noise/Hz), press SHIFT NOISE/Hz ON . This provides for bandwidth conversion for an ideal filter and level compensation for the logarithmic amplifier by the internal CPU, thereby permitting precise measurement.

To return to the normal measurement mode, press SHIFT NOISE/Hz OFF.





4-24. EVALUATION FOR TR4172'S DYNAMIC RANGE BY TWO-SIGNAL RESPONSE

This paragraph shows an evaluation example for the TR4172's dynamic range based on its two-signal response (intermodulation distortion characteristic between the fundamental signal and the 3rd harmonic).

(1) Connect the outputs of two signal generators to the input of the TR4172 via a two-signal measuring pad (two-signal branching unit) (See Figure 4-2). When setting the SG output level, the insertion loss (approximately 6 dB) of the branching unit should be taken into account. If you set the outputs of the two SGs at the same frequency, note the maximum allowable input level of the TR4172 (+20 dBm).

It will help if you have prior information about the signal-to-noise and carrier-to-noise ratios of the two signal generators used.

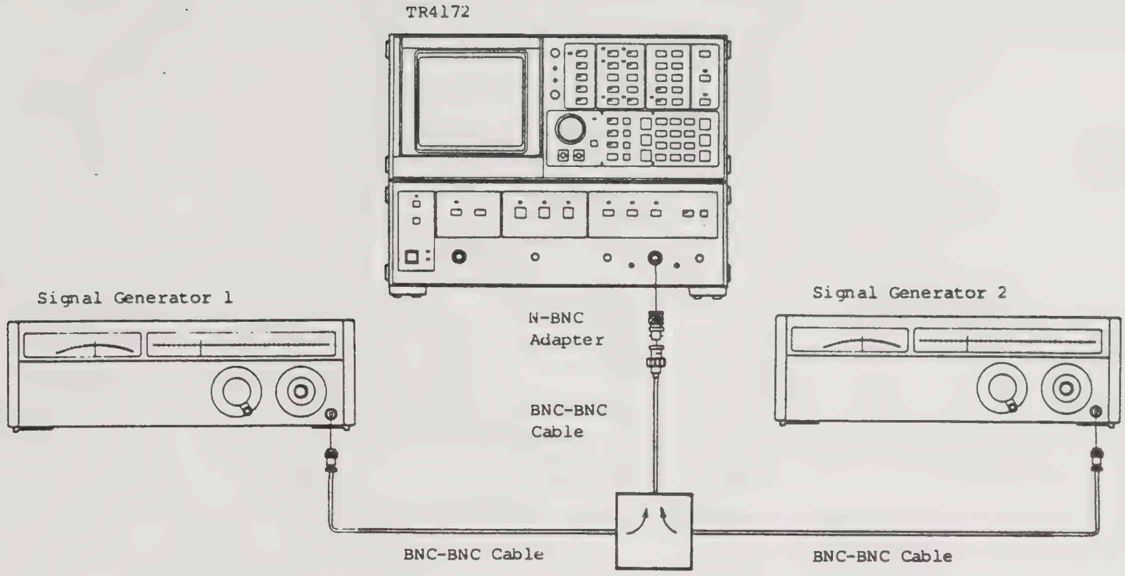


Fig. 4-2 Measurement setup

(2) Set up signal generator output frequencies. In this example, signal generators A and B are set up respectively for 91 MHz and 92 MHz.

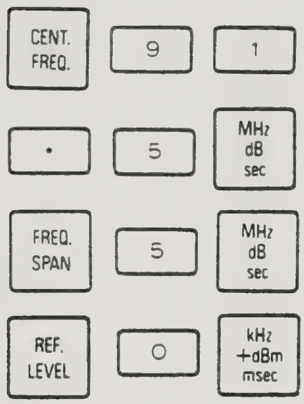
(3) With the TR4172 in the initial default state, prepare it as follows:
Center frequency: 91.5 MHz (middle of the two SG output frequencies)
Frequency span: 5 MHz
Reference level: 0 dBm

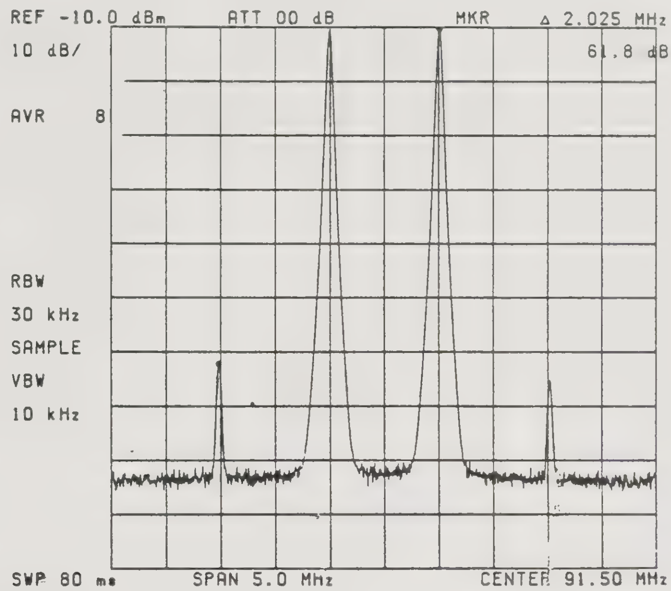
(4) If the noise level is too high, manually narrow resolution bandwidth (initially set at the AUTO mode). Note, however, that a resolution bandwidth set too narrow will make the sweep time too long.

(5) Execute averaging if needed. When executing averaging, select a number of averaging repetitions (such as 8 or 16) fewer than the initial averaging number setup of 128 because this number will make analysis time too long.

[SHIFT] [AVG. ON] [8] [Hz/-dBm/μsec] (Initiates 8 repetitions of averaging sequence.)

(6) The TR4172 has a display dynamic range of 95 dB. Adjust the reference level (while reducing the SG output levels) to search for the maximum sensitivity. If necessary, adjust the input attenuator as well.





(7) Read the difference between the input level and distortion level with the delta marker (see Figure 4-3).
The two-signal characteristic represents the intermodulation distortion between the fundamental wave and the 3rd harmonic. It implies the anti-saturation characteristics of the mixers or amplifiers used in the spectrum analyzer.

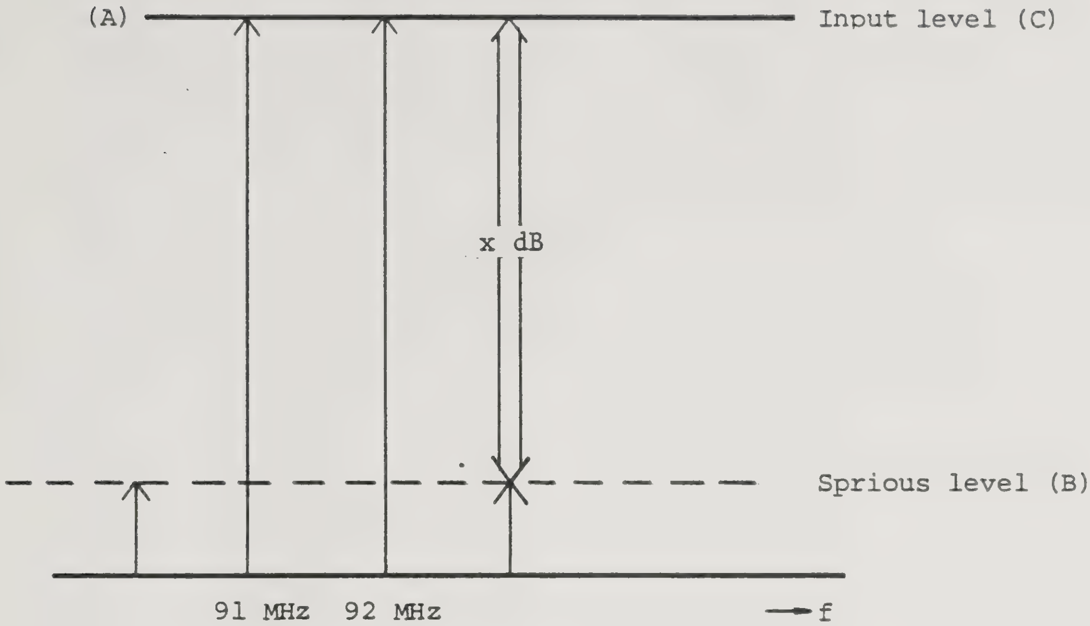


Fig. 4-3 Two-signal characteristic measurement

The intersection of the fundamental wave and the 3rd harmonic distortion is called the intercept point. It is expressed by an absolute value of the input such as XX dBm.
To determine the intercept point from the measured data, use the following formula:

$$\frac{A - B}{2} + C$$

A = Two-signal input level (dBm)
B = Spurious level (dBm)
C = Input level (dBm)

In the above example, the intercept point of the TR4172 is +20 dBm.

4-25. SIMULTANEOUS MEASUREMENT OF THE 2ND AND 3RD HARMONICS OF A RADIO TRANSMITTER

This paragraph describes simultaneous measuring procedure for the fundamental, 2nd harmonic, and 3rd harmonic outputs of a 144 MHz radio transmitter.

(1) Apply the output of the transmitter to the input of the TR4172 Spectrum Analyzer via the TR1625 RF Coupler (see Figure 4-4). The TR1625 RF Coupler has an attenuation level of 40 ±1 dB over a frequency range between 0 MHz and 1000 MHz. If the output power of the transmitter is 10 W, it is attenuated to 100 W/50 Ω (-10 dBm) when

applied to the input of the TR4172.

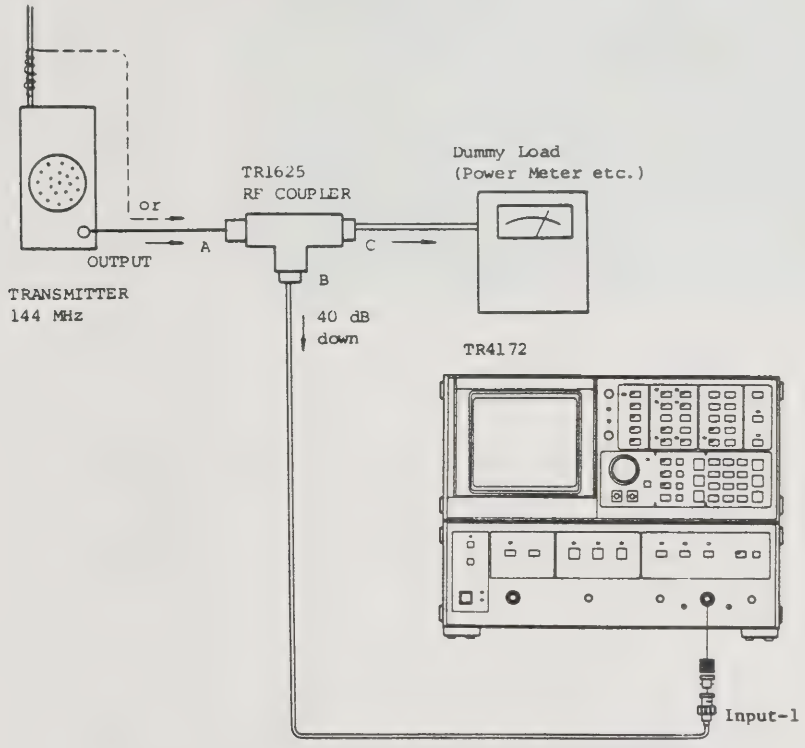
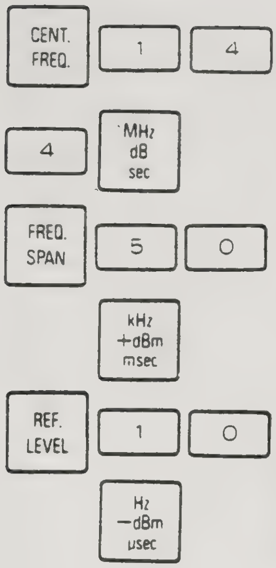
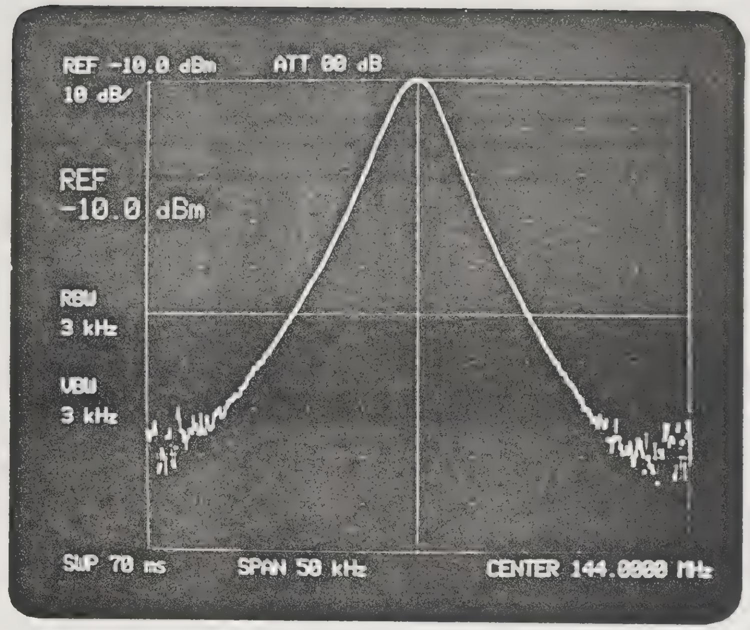


Fig. 4-4 Measurement setup

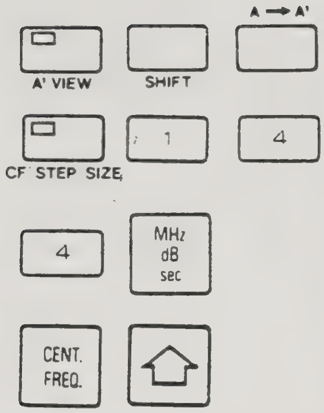
(2) When the analyzer is in its initial default state, set the center frequency to 144 MHz, frequency span to 50 kHz, and reference level to -10 dBm.

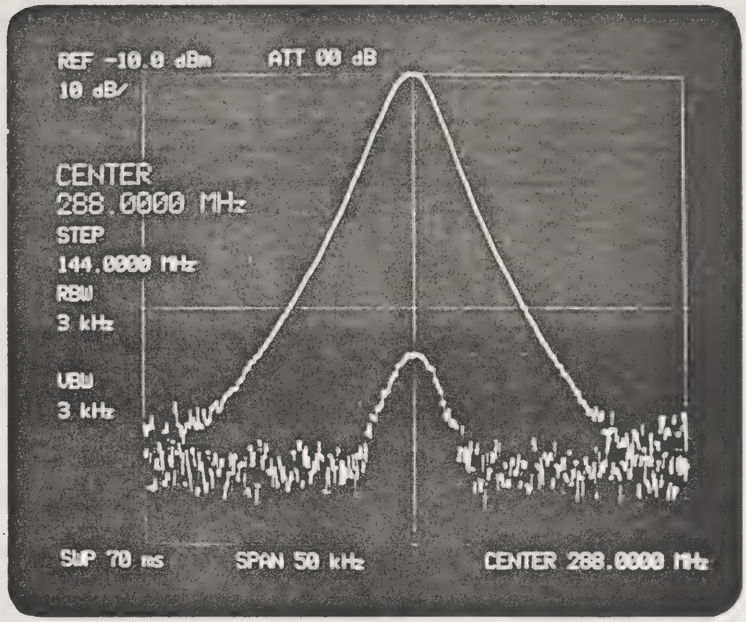




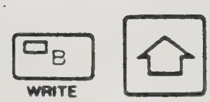
(3) Since the WRITE A mode is the initial default selection, the fundamental response trace is stored in trace memory A. Transfer this trace information into memory A' by pressing A' VIEW, SHIFT, A → A'.

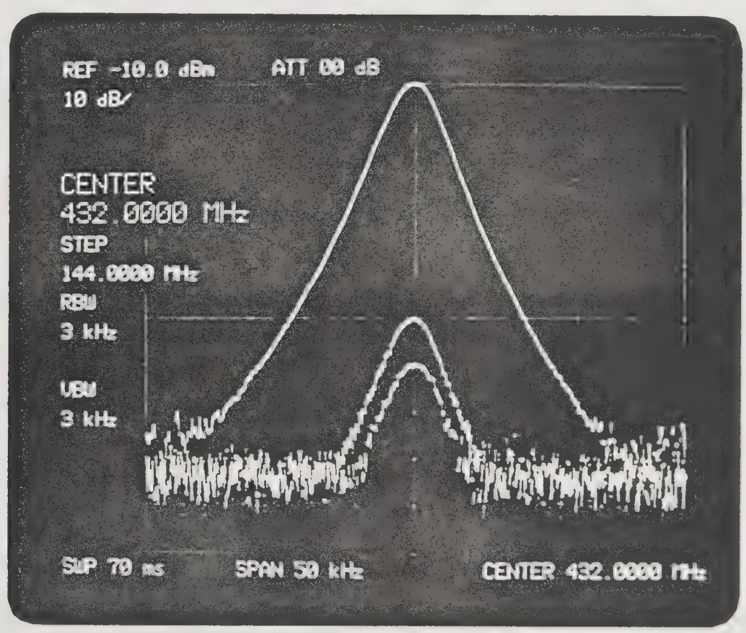
(4) Next, double the center frequency setting to observe the 2nd harmonic in the transmitter output. If the center frequency step size is set to 144 MHz, the center frequency will be multiplied in an integral sequence (double, triple and so on) each time the STEP UP key is pressed. Use trace memories A, A', and B to superimpose higher harmonics on the fundamental response trace.





(5) Press the WRITE B key. Memory A will be automatically placed in the VIEW (still) mode. Observe the 3rd harmonic response on active display B.





(6) The three signal response traces are now simultaneously available on the screen. If you also wish to observe the 4th response trace press the B B' key to store the 3rd harmonic response into memory B', then store the 4th response into the active trace memory B.

(7) To clear the fundamental response trace from the display, press SHIFT A' BLANK. Other response traces can also be cleared from the display with similar operation.

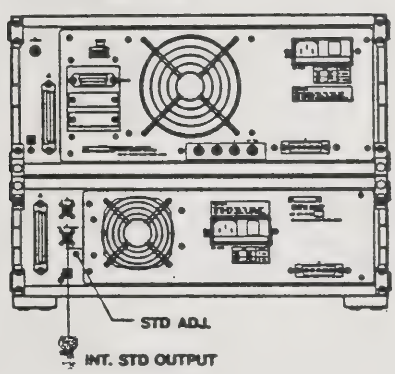
4-26. INTERNAL STANDARD OUTPUT ON/OFF

When the $\boxed{}$ (SHIFT), $\boxed{}$ (LABEL), and $\boxed{7}$ keys are pressed sequentially, the 10 MHz standard oscillator output is output from the INT. STD OUTPUT (J4) connector at the TTL level.

Measure this output with a more precise counter or frequency standard and comparator, then adjust it with the STD ADJ. control to accurately set the output to 10 MHz.

Pressing the $\boxed{}$ (SHIFT), $\boxed{}$ (LABEL), and $\boxed{8}$ keys sequentially will cut off the internal reference oscillator output. This output is cut off when this instrument is initialized by power on operation or by pressing the MASTER RESET key.

TR4172 (Rear Panel)



4-27. ADJACENT CHANNEL LEAKAGE POWER ARITHMETIC OPERATION SOFTWARE (OPTION 06)

The data on trace A measured by TR4172 is divided into 1001 points on the frequency axis, the power equivalent to the width specified by the delta marker is integrated, and the ratio of the integration result to the total power is displayed on trace B.

When Pn is the power between each points on screen A, total power P is obtained from:

$$P = \sum_{n=1}^{1001} Pn$$

When ΔX is the width of a delta marker, data P_{ADJ} on screen B after arithmetic operation is obtained from:

$$P_{ADJ} = 10 \log \frac{\sum_{n-\Delta X/2}^{n+\Delta X/2} Pn}{P}$$

Two methods for integration by the ΔX width can be selected: ideal filter (ΔX width) and trapezoidal filter (ratio of 90 dB/6 dB is set in the range of 1.0-9.99).

The adjacent channel leakage power arithmetic operation procedure is as follows:

(1) Measure the waveform on trace A.

(2) Press the VIEW A key to freeze the trace. Specify the integration width by the delta marker.

(3) Operate [ ] SHIFT, [ ] LABEL, and [1] keys.

(4) Press the [2] key for integration by an ideal filter. Press the [3] key for data only. The ratio (dB) of the adjacent channel leakage power to the total power at the first marker is displayed under ADJ. The frequency at this point is displayed on the upper right of the CRT screen.

(5) Press the [4] key for waveform integration by a trapezoidal filter. To obtain the dB value, press the [5] key, then select

the ratio of 90dB to 6 dB.

When the [1] key is pressed, the ratio is 2.24.

When the [2] key is pressed, the ratio is 1.75.

When the [3] key is pressed, the ratio is 1.66.

When the [4] key is pressed, any ratio may be set in the range of 1.0-9.99.

In this case, input the value of 100 X [90dB/6 dB] by the DATA keyboard, then press the [Hz −dBm μsec] key.

The operation time is prolonged as the delta marker width increases. Sometimes, it takes more than one minute.

(6) When the [MKR OFF] u key is pressed, or [CENT. FREQ], [FREQ. SPAN], [REF. LEVEL] keys are operated, the ordinary measurement mode is selected.

(7) If the [MARKER] and [B VIEW] keys are pressed after pressing the [MKR OFF] u key, the marker is moved to the integration waveform on trace B. Thus, the ratio (dB) to the total power at any marker point can be read. In this case, press the [SHIFT] and [REF. LEVEL] (REF. OFFSET) keys, input the offset value, and then set the reference level to 0 dB, because the integration waveform is drawn with reference to the total power. Accordingly, if the reference level is set to 0 dB including the offset, the value at the marker can be read out directly. When an integration waveform is drawn, the waveform on both ends of the display become zero waveforms (approximately 1/2 of the integration width).

(8) If the instrument is equipped with both of occupied banwidth display (option 04) and adjacent leakage power arithmetic operation (option 06), occupied bandwidth can be measured by operating [SHIFT], [LABEL], [1] keys and then pressing the [1] key again.

It also can be measured by pressing the [MARKER] key after the measurement of adjacnet leakage power arithmetic operation.

(9) If the [Δ] key is pressed before selecting the ordinary measurement mode by pressing the [MKR OFF] key, the integration trace can be plotted directly by TR9831 or TR9834R plotter.

Note) "ADJ" displayed on the CRT means adjacent.

4-28. X-Y PLOTTER INTERFACE (OPTION 07)

This option is a software program allowing connection to the Hewlett Packard Model 9872A/7470A/7225A Plotter. This option must not be used together with option 03; however, combined use with other options is permited. Read the instruction manual for the purchased plotter before connecting a plotter to the TR4172, switching the plotter power on, or setting the pen. Set the 9872A address to "5", and other plotters' addresses to "listen only". The X-Y plotter interface operating procedure is as follows:

(1) Display the waveform (Smith chart) to be plotted on the TR4172 CRT screen.

(2) Operate the [SHIFT], [LABEL], and [2] keys to load the program.

(3) The following is displayed on the CRT:

9872A : '1'	7470A : '2'
7225A : '3'	QUIT : '4'

Press one of the [1], [2], or [3] key according to the type of the connected plotter.

If the [4] key is pressed, the state before program loading is restored.

If the message above is not displayed instantly,

" ERROR PLOTTER DOWN OR ADDRESS SW. IS NOT "5" OR CONNECTER DRAWN OUT RERUN OR QUIT 1 OR 0 "

is displayed approximately 5 seconds later. If this message is displayed, check if the plotter is powered on, plotter's address switch is set to "5" or "listen only", and connector is properly connected. To execute the plotter program again, press the [1] key. If the [0] key is pressed, the state before program loading is restored.

(4) Then, the following is displayed on the CRT:

ALL : '1' DATA : '2'

QUIT : '3'

To plot all data on the CRT screen, press the [1] key. To display only the waveform, press the [2] key.

If the [3] key is pressed, the state before program loading is restored.

In the Smith chart list mode, plotting starts without displaying the above message.

(5) Then, the characters, which were displayed in the center of the left half of the CRT screen (active area) before program loading, are displayed again and plotting starts.

Table 4-5 Pen numbers

Model \ Trace	TRACE "A"		TRACE "B"	
	A	A'	B	B'
9872A	2	4	3	1
7470A	1	1	2	2

CAUTION

The waveform in the LOG. DISPLAY mode cannot be plotted.

(6) If the [SHIFT] key is pressed while the plotter is running, plottting is forcibly stopped and plotter selection menu is displayed on the CRT. Change the plotting paper and follow the operaiton procedures from item (3) again.

4-29. N dB DOWN WIDTH MEASUREMENT

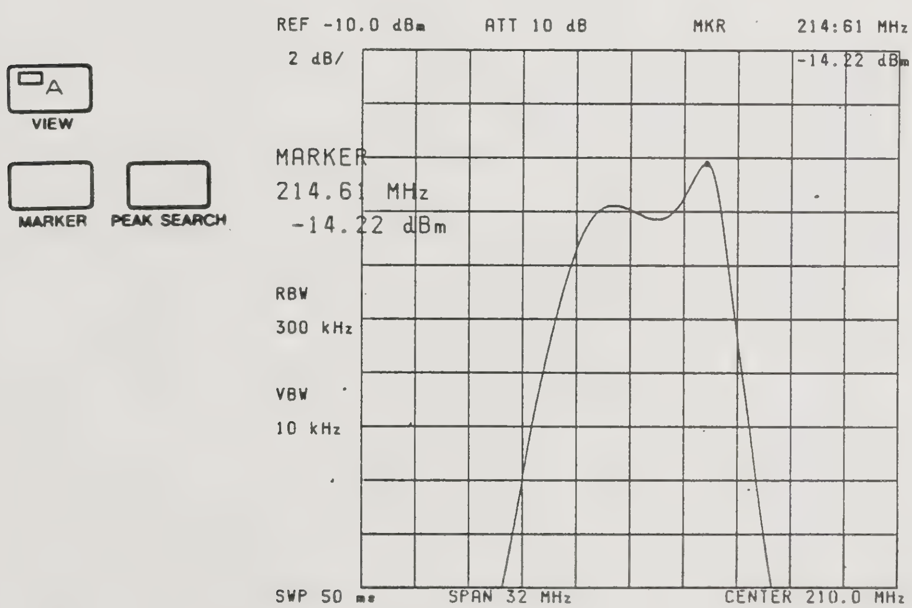
4-29-1. Specification

Displays two markers at the level N dB below the preset marker on the waveform; and displays a frequency differences between the two markers or their frequency differences with respect to the center frequency, and the frequency and amplitude level of the left marker.

4-29-2. Operating Procedures

(1) This mode can be used when the vertical scale is in the logarithmic scale of 10 dB/div to 1 dB/div.

(2) Set the waveform in the VIEW mode to freeze it. Display a regular marker and move it to the desired peak.

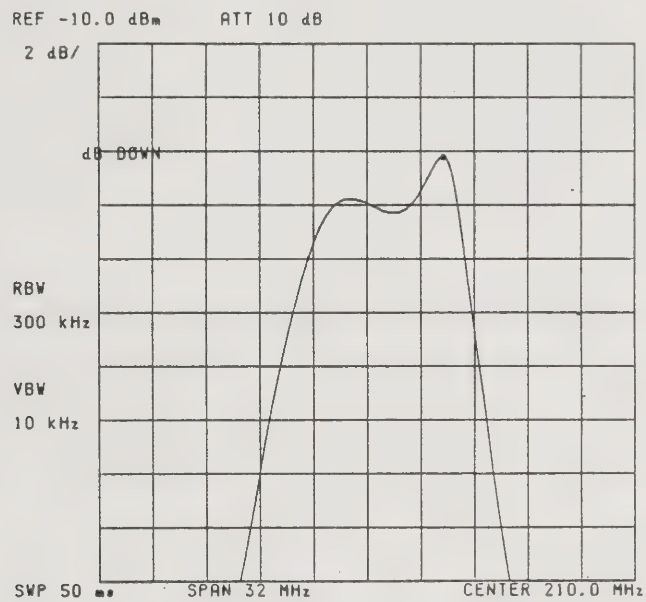


(3) Press the [SHIFT], [LABEL], and [MARKER] keys in this order. This option program is loaded and this mode becomes active. "dB DOWN" is displayed in the active function area at the middle left of the CRT.

If this key operation is performed when the regular marker is not displayed or when the delta marker is displayed, the analyzer enters the NEXT PEAK mode.

[SHIFT] [LABEL]

[MARKER]



(4) Enter a down level from the peak using the DATA keyboard. Acceptable data is from 0.1 dB to 99.9 dB.

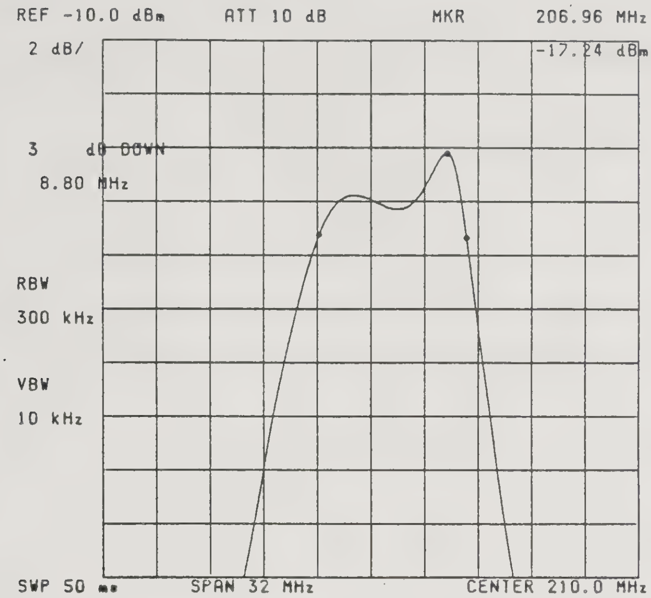
(Example)

[1] [0] [•] [5] ..... 10.5 dB

(5) Press the [MHz dB sec] or [kHz +dBm msec] key. A marker is displayed at the right and left side points on the waveform N dB (input value) below the preset marker.

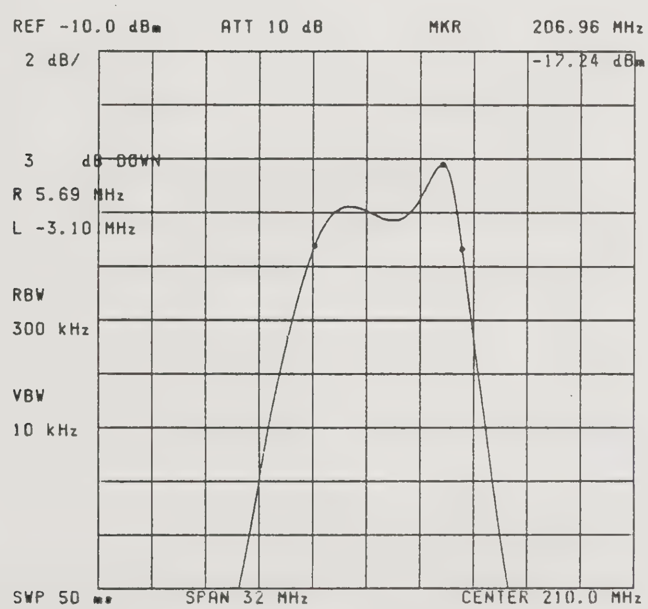
A frequency differences between the right and left markers is displayed in the active function area at the middle left of the CRT when the [MHz dB sec] key is pressed,

MHz dB sec



and a frequency differences of the left marker (headed by "L") and right marker (headed by "R") with respect to the center frequency when the kHz +dBm msec key is pressed.

kHz +dBm msec



In both cases, the frequency and amplitude level of the left marker are displayed in the marker area at the upper right corner of the CRT.

"ERROR" is displayed in the active function area when an entered value is beyond the required size (0.1 dB to 99.9 dB) or when the waveform does not exist at the level N dB below the preset marker. In such a case, repeat the operation from step (4) again.

(6) Operation from step (4) can be repeated.

(7) The following three ways are available to exit from this mode:

- o Press the [MKR OFF] key. Execution exits from this mode with the marker off.
- o Press the [MARKER] key. Execution exits from this mode with the central marker changed to the normal marker.
- o Press the [Δ] key. Execution exits from this mode with the right and left markers changed to the delta markers.

When a function key other than the above is pressed, execution exits from this mode. In this case, however, the marker is not cleared. So, press the [MKR OFF] key to clear the marker after setting this mode again.

To set N dB DOWN WIDTH mode after exiting from this mode, start from the beginning.

4-29-3. Operation by GPIB

The remote operation by GPIB is performed accordingly, by programming codes corresponding to the panel keys operated in the manual operation in the same order.

4-30. NEXT PEAK SEARCH FUNCTION

4-30-1. Specification

Displays positive peaks in descending size order, negative peaks in ascending size order, or positive and negative peaks in left-to-right order in the section specified on the waveform by the delta marker.

4-30-2. Operating Procedures

(1) Set the waveform in the VIEW mode before using this mode.

(2) Specify the section to be measured by the delta markers.

(3) Press the [SHIFT], [LABEL], and [MARKER] keys in this order. This option program is loaded and this mode becomes active.

The following messages are displayed in the active function area at the middle left of the CRT:

POS. NEXT: 'R'
NEG. NEXT: 'S'
LEFT NEXT: 'T'

If this step is performed with no marker displayed, a marker is displayed at the right and left ends of the trace. Then, these two markers become the delta markers.

If this step is performed with the regular marker displayed, the analyzer enters the N dB DOWN WIDTH mode.

(4) When the [ ]R key is pressed, a marker is displayed in the position of the maximum positive peak in the section specified by the delta markers, and its frequency and amplitude level are displayed.

Then, every time the [PEAK SEARCH]v key is pressed, a positive peak in the section specified by the delta markers is displayed in descending size order. The place of a displayed peak in a series is displayed in the active function area.

When the [ ]S key is pressed, a marker is displayed in the position of the minimum negative peak in the section specified by the delta markers, and its frequency and amplitude level are displayed.

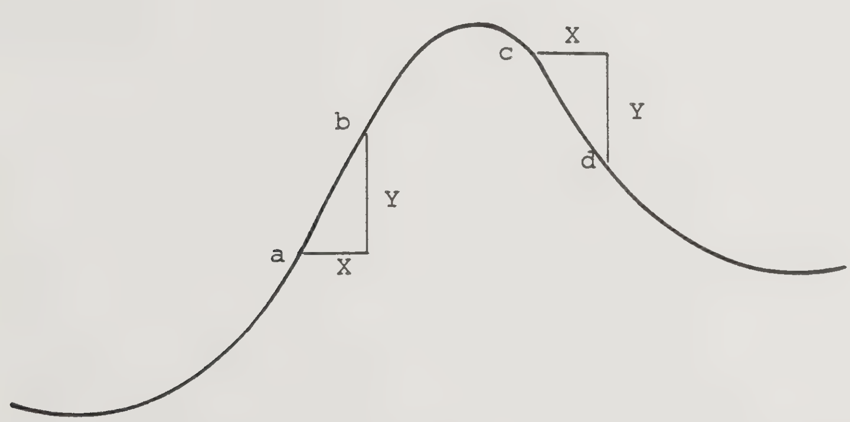
Then, every time the PEAK SEARCH v key is pressed, a negative peak is displayed in the section specified by the delta markers in ascending size order. The place of a displayed peak in a series is displayed in the active function area.

When the T key is pressed, a marker is displayed in the position of the leftmost peak in the section specified by the delta markers, and its frequency and amplitude level are displayed.

Then, every time the PEAK SEARCH v key is pressed, peaks in the section specified by the delta markers, both negative and positive, are displayed in left-to-right order. The place of a displayed peak in a series of positive or negative peaks--"+N" or "-N"--is displayed in the active function area.

(5) To exit from this mode, follow the procedure outlined in step (6) of paragraph 4-29 "N dB DOWN WIDTH MEASUREMENT".

(6) To obtain, for example, the maximum positive value by using this program, point a where the slope of the waveform exceeds $\Delta Y/\Delta X$ is obtained. Next, point d of a slope of $-\Delta Y/\Delta X$ is obtained. Then, the maximum value between these two points is obtained.



The initial values of ΔX and ΔY are 20 and 5 points respectively for a CRT resolution of 1001 x 1001 points. By changing ΔX and ΔY, the sensitivity of peak detection can be changed.

For instance, the entry " $\boxed{}$X $\boxed{3}$ $\boxed{0}$ $\boxed{\begin{matrix}\text{Hz}\\ -\text{dBm}\\ \mu\text{sec}\end{matrix}}$ " from the DATA keyboard sets ΔX to 30 points. The entry " $\boxed{}$Y $\boxed{2}$ $\boxed{0}$ $\boxed{\begin{matrix}\text{Hz}\\ -\text{dBm}\\ \mu\text{sec}\end{matrix}}$ " sets ΔY to 20 points.

The number of points, both ΔX and ΔY, can be set within the 1 to 255 range.

4-30-3. Operation by GPIB

The remote operation by GPIB is performed accordingly, by programming codes corresponding to the panel keys operated in the manual operation in the same order.

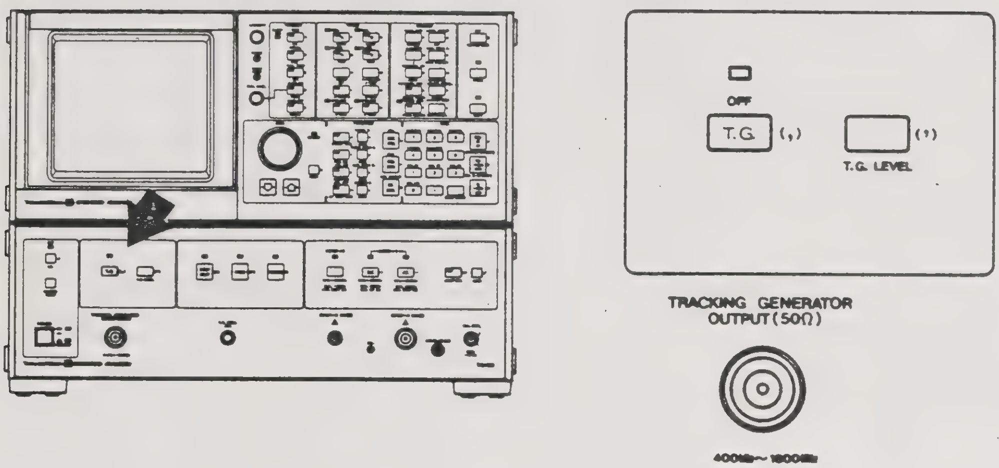
4-31. START/STOP FREQUENCY SETTING

In addition to setting the center frequency and frequency span, this device sets start and frequencies by pressing [SHIFT], [6], [1]. In this mode, the [CENT. FREQ.] switch is used to set the start frequency and the [FREQ. SPAN] switch is used to set the stop frequency. The setting resolution of the frequency difference between the start and stop frequencies is the same as the one set in the normal center frequency and frequency span setting modes.

By pressing either the MKR→CF switch or the SIGNAL TRACK switch in the start/stop frequency setting mode, the stop frequency display in the lower right corner of the screen is changed to the center frequency display.

SECTION 5

TRACKING GENERATOR OPERATIONS



5-1. OPERATING TRACKING GENERATOR

(1) Press the POWER switch to the ON (in) position.

(2) Set up the analyzer for the following conditions:

Center frequency	900 MHz
Frequency span	1800 MHz
Reference level	−10 dBm
Resolution bandwidth	300 kHz
Input attenutator	10 dB

(3) Press the T.G. key to activate the tracking generator; the indicator lamp just above the key lights.

(4) The T.G. LEVEL key, when pressed, enables output attenuation level for the tracking generator to be controlled in 10 dB steps using the DATA step keys.
Press the T.G. LEVEL key and set the tracking generator's output attenuator to 10 dB using the DATA step keys.

(5) Connect the TRACKING GENERATOR OUTPUT connector to the INPUT connector with a coaxial cable. The CRT display will present a through frequency response.

(6) Disconnect the coaxial cable from the INPUT connector and then reconnect it to the input of the device under test.
Press the T.G. LEVEL key and set the tracking generator's output attenuator to an appropriate level between 0 dB and 50 dB. The output impedance of the tracking generator is approximately 50 Ω.

(7) Connect the output of the device under test to the INPUT connector of the analyzer using another coaxial cable. The input impedance of the analyzer is approximately 50 Ω.

(8) The noise level can be lowered and hence a broader dynamic range can be obtained by narrowing the IF bandwidth using the RES. BW key. Note, however, that a resolution bandwidth reduced below 100 Hz can cause a tracking error (deviation of tracking generator's output frequency from analyzer's tuning frequency), which eventually results in a level error. In this case, adjust the displayed signal level to the maximum with the T.G. FREQ. ADJ. control. Set the frequency span to 10 kHz, sweep time to relatively long, and step down resolution bandwidth from 300 Hz to 100 Hz, 30 Hz, and 10 Hz while adjusting the T.G. FREQ. ADJ. control until the maximum signal level is obtained.

(9) To disable the tracking generator, press [SHIFT] [T.G. (OFF)]; the indicator lamp above the T.G. key will go off.

5-2. FREQUENCY RESPONSE COMPENSATION USING A DISPLAY LINE

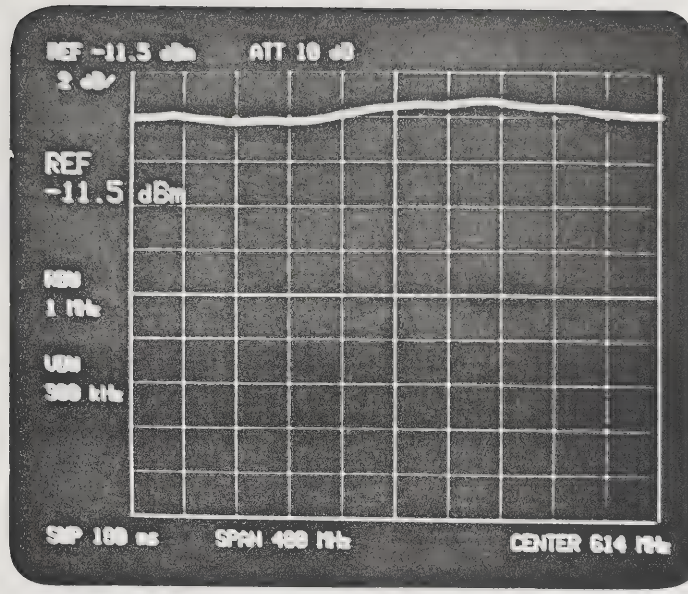
This paragraph describes frequency response compensation for the spectrum analyzer itself or an interconnecting cable (for filter response measurement, etc.) by using the TRACE function and a display line.

5-2-1. Compensation Using the SHIFT and MHz Keys

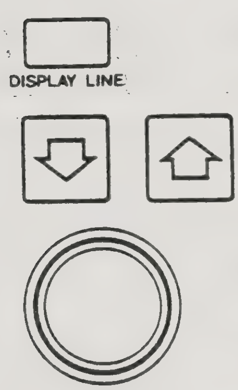
(1) Press the WRITE A key to place the analyzer in the WRITE A mode.

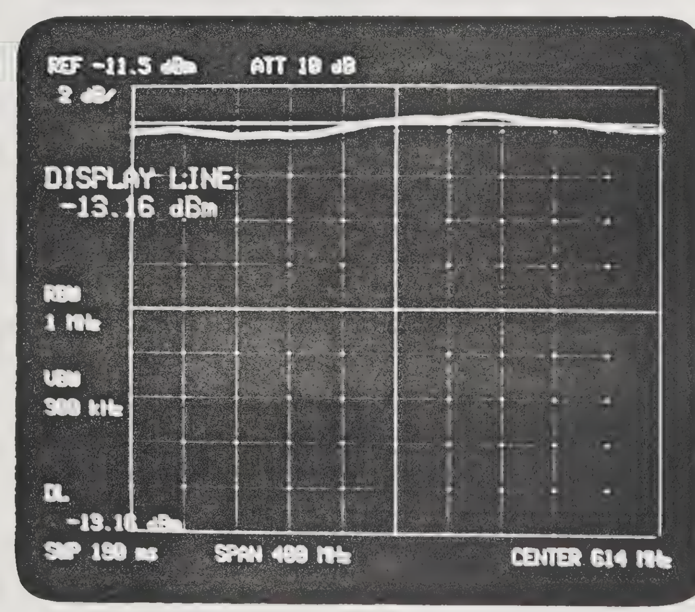
(2) Disconnect the device under test from the measuring setup and connect the TRACKING GENERATOR OUTPUT connector to the INPUT connector of the analyzer directly with a coaxial cable.

(3) Press the REF. LEVEL key and adjust the reference level with the DATA knob and/or DATA step keys until the through frequency response is lowered to the level shown in the following figure:

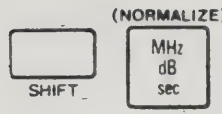


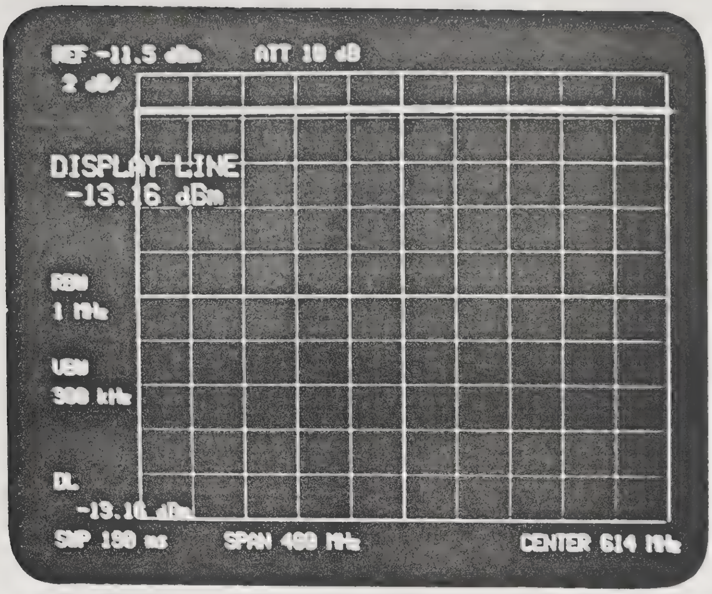
(4) Press the DISPLAY LINE key to activate a display line.
Using the DATA step keys and DATA knob, position the display line close to the through signal response.
A broader dynamic range can be obtained as the display line is positioned closer to the through signal response.





(5) Analyzer's frequency response compensation is accomplished by pressing the SHIFT and MHz keys as below:



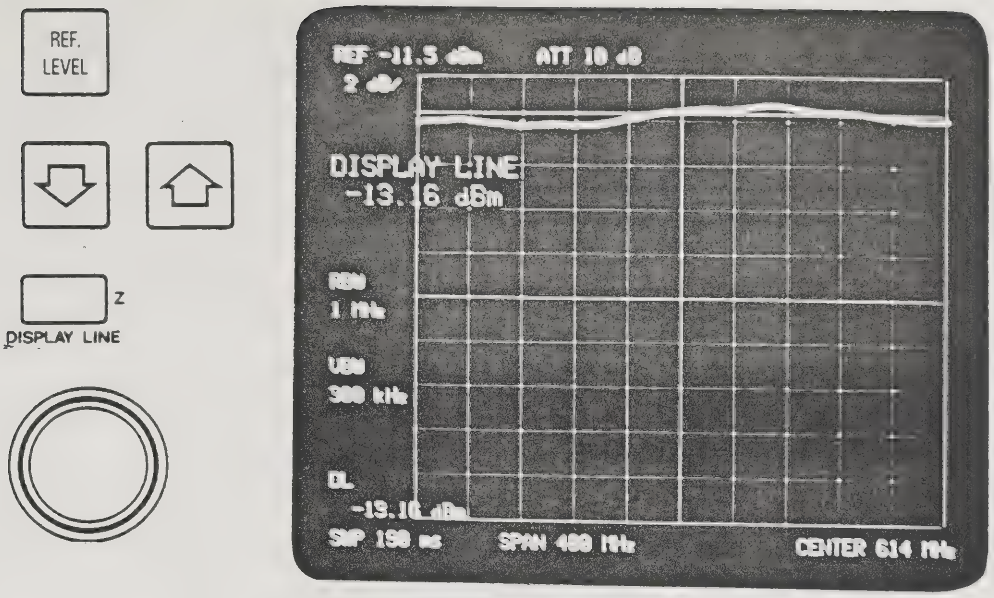


(6) The compensation procedure described in steps (1) through (5) above is an automatic version of the procedure using the B-DL→B and A-B→A keys which will be described in the following paragraph. Therefore, the analyzer is placed in the A-B→A mode after the frequency response compensation is completed and the indicator lamp on the A-B→A key lights.
To disable frequency response compensation press the SHIFT and A-B→A keys to clear the A-B→A mode. Do not press 

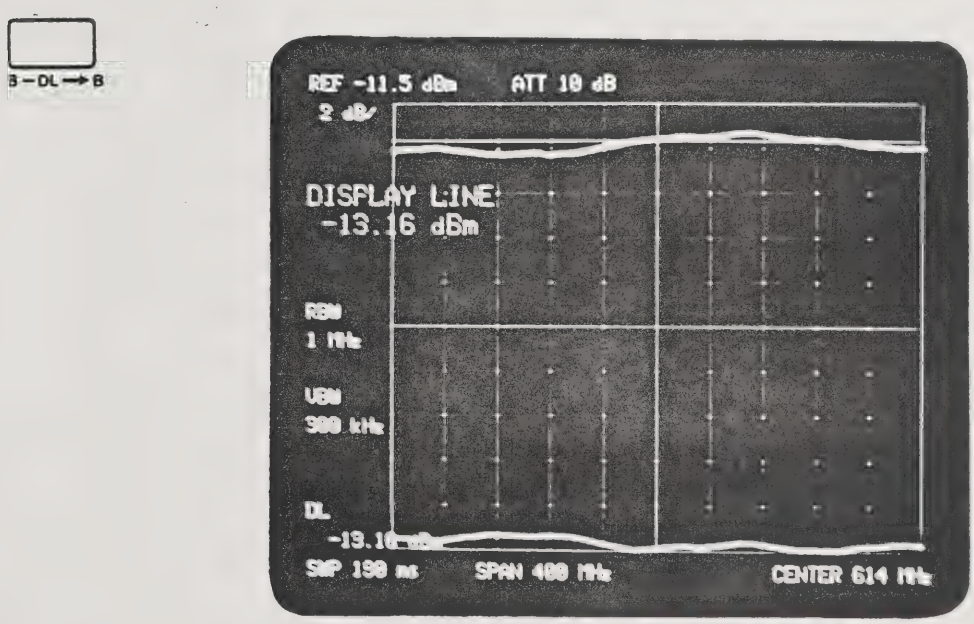
switch when this mode is used.

5-2-2. Compensation Using the B-DL→B Key

(1) Press the WRITE B key to place the analyzer in the WRITE B mode.
(2) Disconnect the device under test from the measuring setup and connect the TRACKING GENERATOR OUTPUT connector to the INPUT connector of the analyzer directly with a coaxial cable.
(3) As described in paragraph 5-2-1, activate a reference level and display line, and position the display line close to the through signal response.

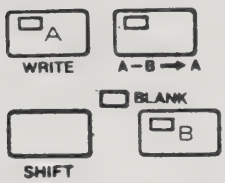


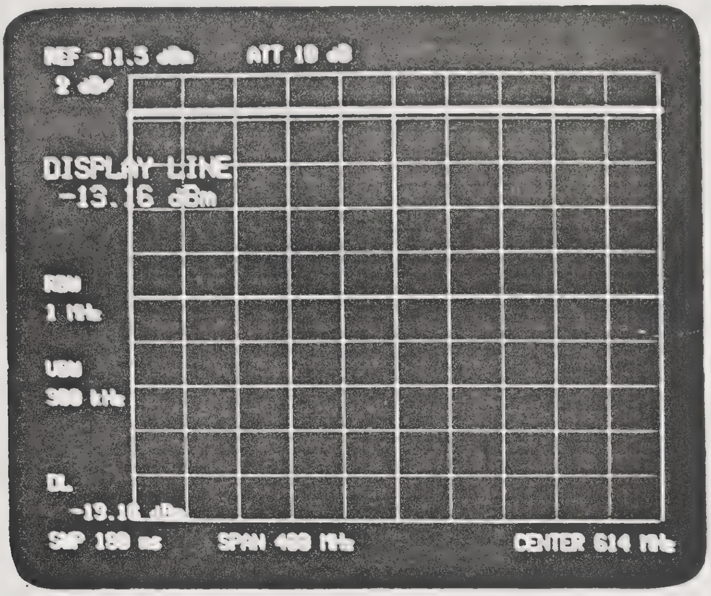
(4) Press the B-DL→B key. The difference between the through signal response and the display line is written into memory B and then transferred to the CRT display.
Memory B is placed in the VIEW B mode.



(5) Press the WRITE A key and then A-B→A key.
Connect the device under test to the measuring setup.
The frequency response is now compensated and displayed on the CRT.

(6) It is advisable that the SHIFT and B BLANK keys be pressed to erase trace B from the display.





(7) Compensation for this frequency response is executed while the LED in the A−B→A switch illuminates. This mode is called as a normalize mode. In the normalize mode, the B WRITE key is not usable, since normalizing operations are performed on data for each sweep using memory B.

(8) If the both display mode is desired while normalization is being performed, use memories A and A'. Note, however, that the previous contents of memory A' may be modified if normalization using SHIFT and (NORMALIZE) MHz dB sec is performed (see 5-2-1). The contents of memory A' will not be affected if normalization is executed with the A−B→A key (See 5-2-2).

(9) In the normalize mode, the alternate sweep feature is not available, since memory B is not usable.

(10) Operation of SHIFT OFF A−B→A clears the normalize mode, with the LED in the A−B→A key turned off.

(11) Before executing normalization, select BLANK A' & BLANK B' mode, or VIEW A' & VIEW B' mode.

5-3. IF QUARTZ FILTER MEASUREMENT USING TRACKING GENERATOR

This paragraph provides on example of how to measure the insertion loss, ripple, 3 dB bandwidth, and attenuation of a communication purpose IF quartz filter using the tracking generator of TR4172.

(1) Connection

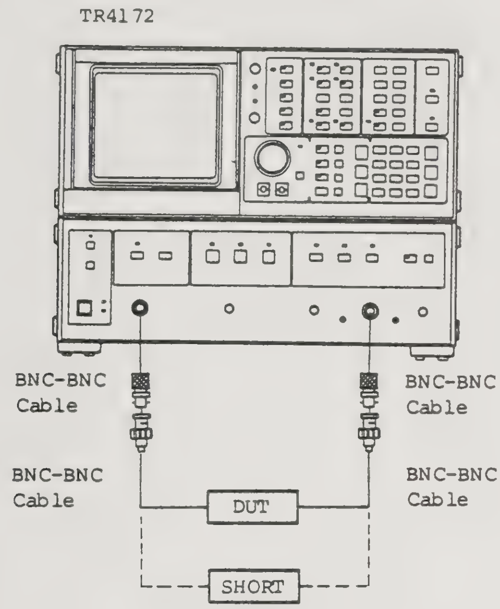


Fig. 5-1 Connecting the filter to the analyzer

(2) Connection precautions

(a) If the input and output impedance of the DUT are different from those (50-Ω) of the analyzer, use appropriate matching means to obtain impedance matching.

(b) If the insertion loss of the filter is too great, insufficient measuring dynamic range may result. If this occurs, use the optional preamplifier at the input of the analyzer (option 02).

(3) Measuring procedure

The following procedure assumes that the DUT is a bandpass filter having the following characteristics:

- Center frequency: 70 MHz
- Pass bandwidth: 25 kHz
- Insertion loss: Less than 5 dB

. Ripple: Less than ±1 dB

. Attenuation : More than 70 dB

(a) Set up the analyzer for 70 MHz center frequency, 100 kHz frequency span, 0 dBm reference level, and 10 dB input attenuator. (Note)

(b) Activate the tracking generator output and check the T.G. output level with the DUT disconnected as shown in Figure 5-1. (b). The T.G. output level should be 0 dBm when the input attenuator is set 0 dB.
Since the frequency span is 100 kHz, the display will show a horizontal straight line. However, perform normalyze as follows:
Press [DISPLAY LINE], then use [⇧] or DATA knob to position the display line to an appropriate level near the top graticule.
Now press [SHIFT] [MHz dB sec (NORMALIZE)] in the WRITE A mode to adjust the response.
If the normalizing should be cleared, press [SHIFT] [A−B→A (OFF)].

(c) Connect the DUT as shown in Figure 5-1 (a). The insertion loss of the DUT is now read as the level difference between the marker point and display line.

Note: In the above example, the insertion loss is defined at the center frequency. In some cases, it may be defined at the peak or average of ripple.

(d) Now the pass bandwidth of the DUT (3 dB down points both sides of the center frequency) is determined as follows:

1. Press [MARKER] [Δ], then use the Data knob to search for the 3 dB down point.
2. When the 3 dB point is found, press [Δ] again.
3. Use the DATA knob to read the frequency at which the level is 0 dB. This frequency denotes the 3 dB pass bandwidth.

(e) Ripple measurement

1. Press [PEAK SEARCH] [MKR → REF.] to position the maximum peak of the signal response to the reference level.

2. Press [SHIFT] [4 (1dB/DIV.)] to change the vertical scale from 10 to 1 dB/div.

   Note: Clear the adjustment mode if it has been selected.

3. Press [PEAK SEARCH], [Δ], then use the DATA knob to read the difference between the maximum and minimum peak level. This difference denotes the ripple level.

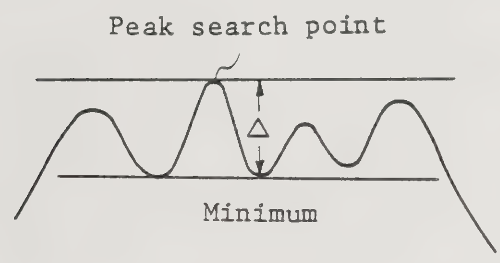


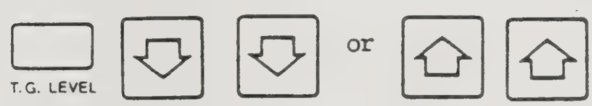
Fig. 5-2 Ripple level

(f) Attenuation measurement

1. If the vertical scale was expanded through the above measurement, to 1 dB/div. for example, return it to 10 dB/div. Press [SHIFT] [7 (10dB/DIV.)] (returns to 10 dB/div.)

Note: If the insertion loss of the DUT is too great, the measuring dynamic range is reduced accordingly. To maintain the dynamic range, use a preamplifier at the input of the analyzer. (See Figure 5-2.) Whether the preamplifier is to be inserted in the input or output of the DUT will depend on the condition of the DUT itself. The characteristics of the preamplifier (amplification factor, frequency response, noise figure, maximum input, VSWR, and input impedance) should be checked beforehand.

The preamplifier (option 02) can be integrated in the TR4172. In this case, however, it cannot be inserted in the input of the DUT.
If the T.G. output level is too high, it can be attenuated by up to 50 dB at 10 dB steps as follows:



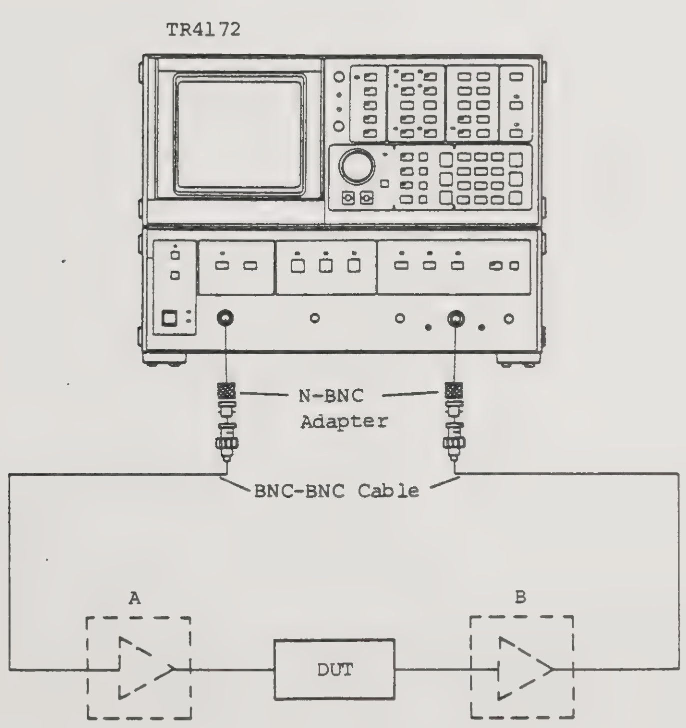


Fig. 5-3 Connecting filter and TR4172 via preamplifier

2. Connect the DUT to the instrument. The following measurement information will be obtained for a band-pass filter (select an appropriate frequency span for this measurement):

Press [PEAK SEARCH], [Δ], [⇩], [⇩] or [⇧], [⇧].

Using the delta marker, measure the attenuation (X dB).

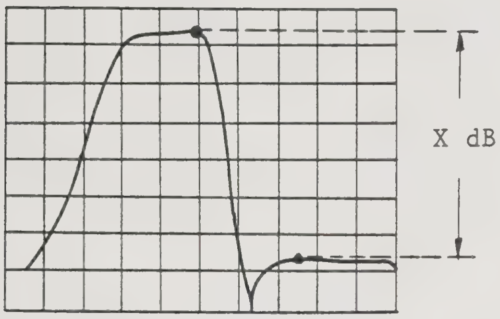


Fig. 5-4 BPF attenuation measurement

SECTION 6

PHASE MEASUREMENT

6-1. PHASE MEASUREMENT PROCEDURE

This paragraph describes phase measurement procedure for amplifiers or filters. Before proceeding with phase measurement read SECTION 5 carefully.

(1) Set center frequency, frequency span, resolution bandwidth, sweep time, and other necessary conditions.

(2) Connect the TRACKING GENERATOR OUTPUT to the input of the device under test (amplifier or filter), and connect the output of the device under test to the INPUT of the analyzer. Activate the tracking generator.

(3) Press the NORMAL key to measure the pass-band response of the device under test. According to the measurement result, select the appropriate T.G. LEVEL and INPUT ATT. level.

(4) Then press the PHASE key to select the phase measurement mode. The display will present measurement range XX^{o}/ at its top left corner, and the indicator lamp just above the PHASE key will illuminate. In the Phase Measurement mode press the SWEEP TIME key to manually select the appropriate sweep time (the AUTO mode is programmed for amplitude measurement).

(5) For more precise phase measurement without the affect of phase error of the measuring system, disconnect the device under test from the measuring setup, then connect the input and output cables by using an inline plug adapter to check the phase response of the measuring system itself.

(6) If phase rotation is observed as shown in Figure 6-1, press the kHz G.D. OFFSET key to activate the electrical length.

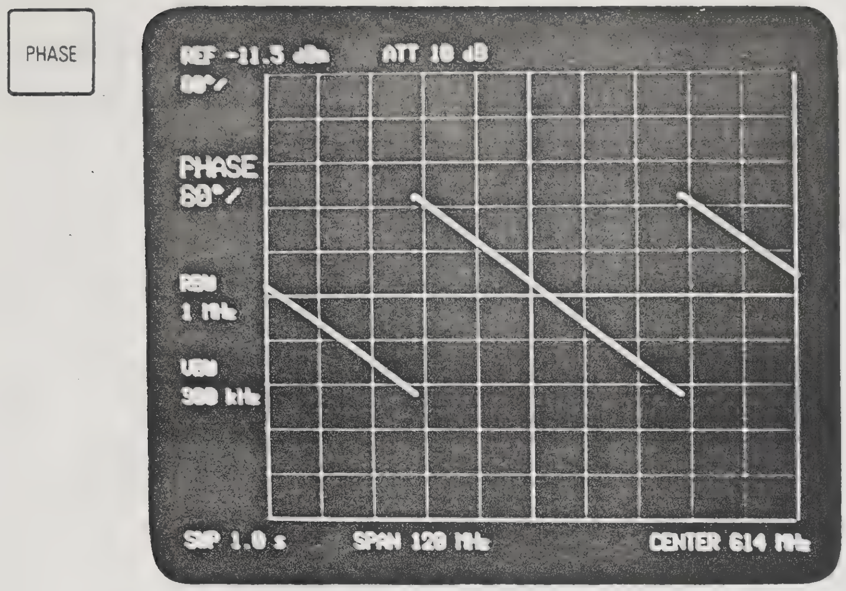


Fig. 6-1 Phase in rotation

Using the DATA knob or DATA step keys (DATA keyboard is not available for this adjustment), adjust the electrical length until a flat phase response is obtained. (See Figure 6-2.) When phase or group delay is activated, the MHz and kHz keys have the PHASE OFFSET and GROUP DELAY OFFSET functions respectively as named below the respective keys. Operation of the SHIFT key is not needed.

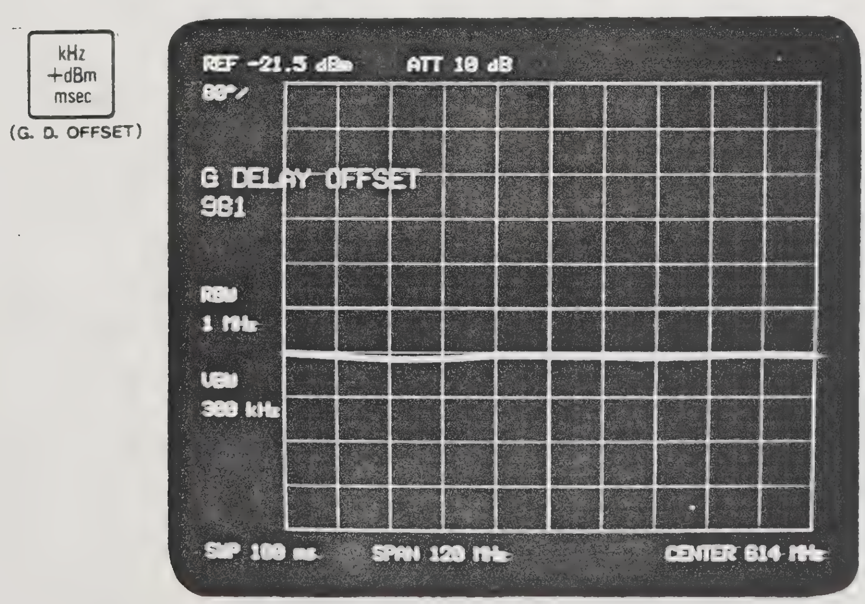


Fig. 6-2 Flat phase response

(7) For fine adjustment of the electrical length, press the G.D. OFFSET key again. This will activate the G DELAY OFFSET FINE mode to permit fine adjustment of the electrical length.

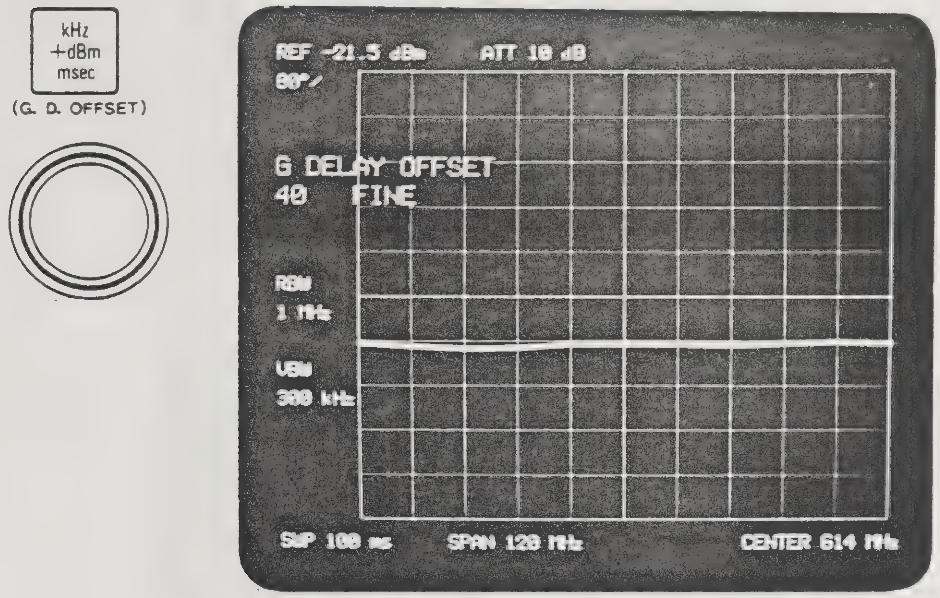


Fig. 6-3 Electrical length fine adjustment

(8) Next press the MHz (PHASE OFFSET) key to activate phase offset, then position the phase response trace at the center of the vertical graticule.

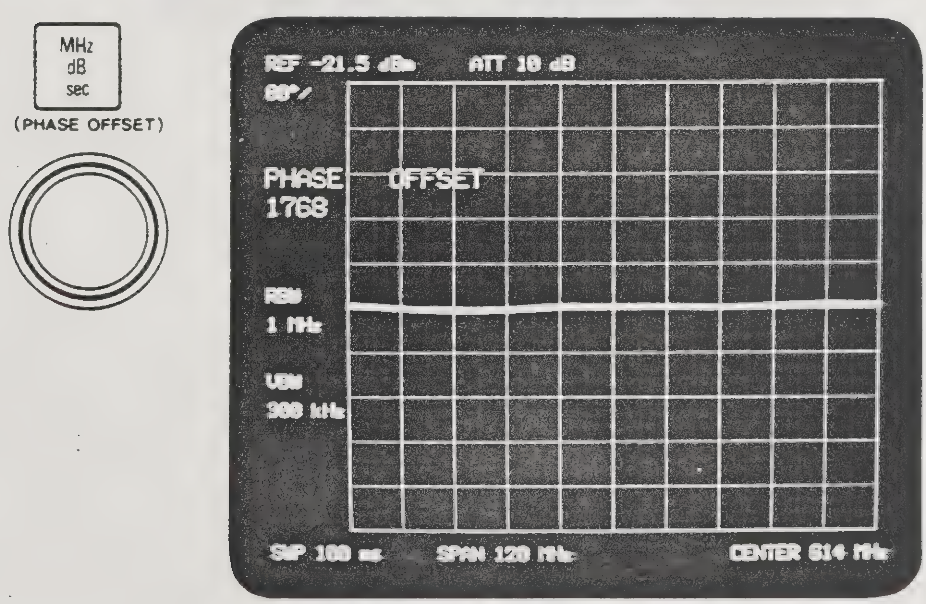
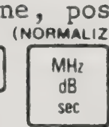


Fig. 6-4 Null phase offset

Verify that a straight line comes to the center of the vertical graticule as shown in Figure 6-4. If the line is not straight, activate a display line, position it to the center of the vertical scale, and press 



to normalize the frequency response.

(9) Connect the device under test to the measuring setup, then press the PHASE key to start phase measurement for the device itself. Operation of the PHASE key will activate phase resolution. Using the DATA knob or DATA step keys, set phase resolution to the appropriate level.

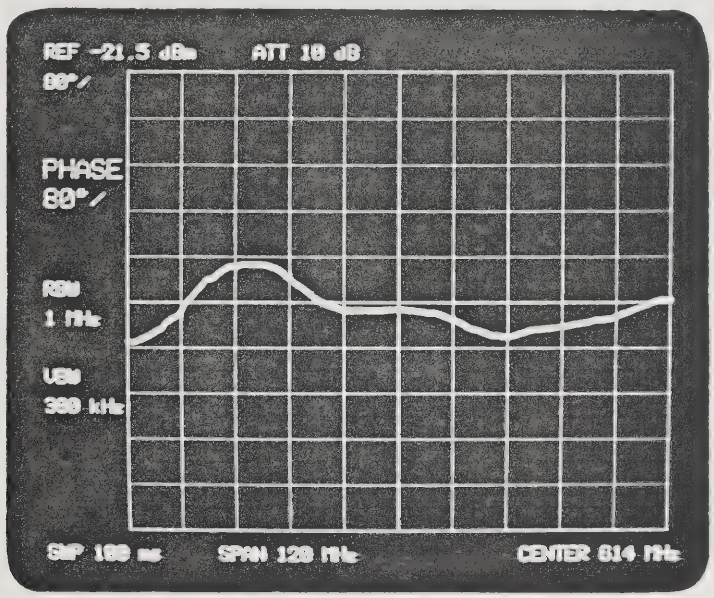


Fig. 6-5 Phase measurement

Note that a higher phase resolution may cause an overflow if the device under test has a relatively large phase rotation.
To observe phase variation, press the (G.D. OFFSET) key and then adjust the électrical length and phase response with the DATA knob. Press the PHASE key again. The phase variation is now enlarged on the display.

6-2. PHASE AND AMPLITUDE ALTERNATE SWEEP (SHIFT, H)

[SHIFT] [D. T. A. P. H] performs phase and amplitude measurements alternately and writes the results into trace memories B and A respectively and then transfers it to the display.

When this mode is selected, the indicator lamps on the WRITE A, WRITE B, PHASE, and NORMAL keys light.

To disable alternate sweep press [SHIFT] [D. T. OFF U HOLD] .

The alternate sweep should not be activated when frequency response compensation using a display line in Section 5 is used.

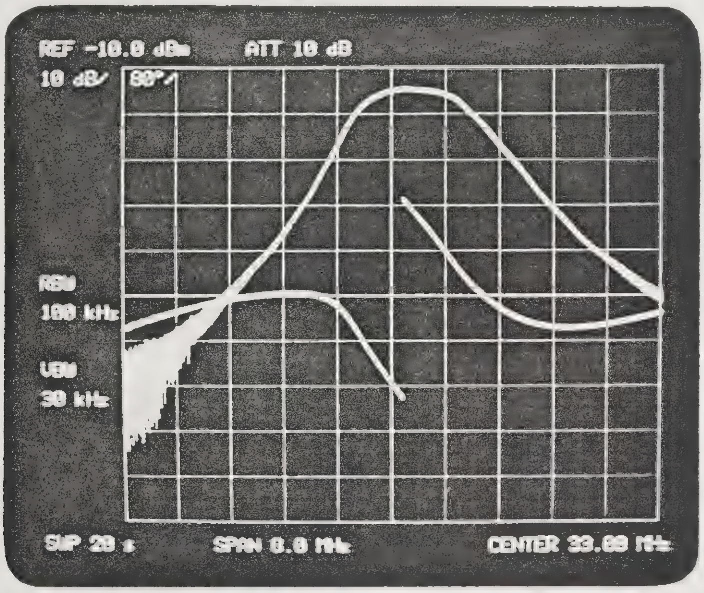


Fig. 6-6 Phase and amplitude alternate sweep

6-3. SAW FILTER PHASE RESPONSE MEASUREMENT

6-3-1. Connecting a Saw Filter to the TR4172

(1) Connect the device under test (DUT: filter) across the tracking generator output and input connectors on the TR4172 as shown in Figure 6-7.

(2) In general, various types of SAW filter are available with input/output impedance of 50 Ω, 75 Ω, 200 Ω, 300 Ω, 1kΩ, and more than 1 kΩ. Before measurement, use an appropriate measure to obtain impedance matching between the SAW filter and the instrument. A schematic diagram of the recommended matching network can be obtained from the manufacturer of the filter.

(3) A saw filter usually has a 20 dB insertion loss. To compensate for this loss, some filters contain an amplifier. If a filter with a self-contained amplifier is to be used, note the maximum output level of the tracking generator.

(4) Use the shortest possible input cables.

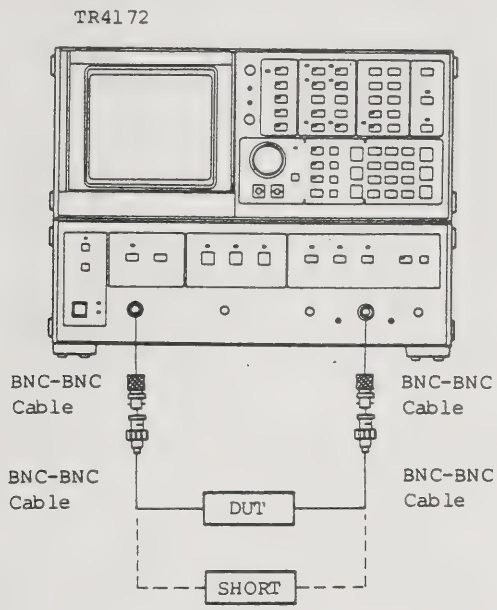


Fig. 6-7 Measuring system setup

6-3-2. Measuring Procedure

(1) Set up the center frequency, sweep span, input condition, and other necessary parameters.

(2) Disconnect the DUT from the cables and connect a shorting device as shown in Figure 6-8.

(3) Press the kHz (G.D. OFFSET) key to obtain a flat phase response. If fine adjustment is required, press the kHz key again to select the G.D. OFFSET FINE mode and perform fine adjustment.

(4) Press the MHz (G.D. OFFSET) key to position the phase response trace to the center of the vertical scale.

(5) Connect the DUT instead of the shorting device, then press the PHASE key; the phase response of the DUT (filter) will be displayed. Display resolution can be increased with the DATA knob or DATA step keys (80, 40, 20, 8, ... 0.2 deg/div.). Figures 6-8 and 6-9 show respectively the amplitude and phase responses of the same filter.

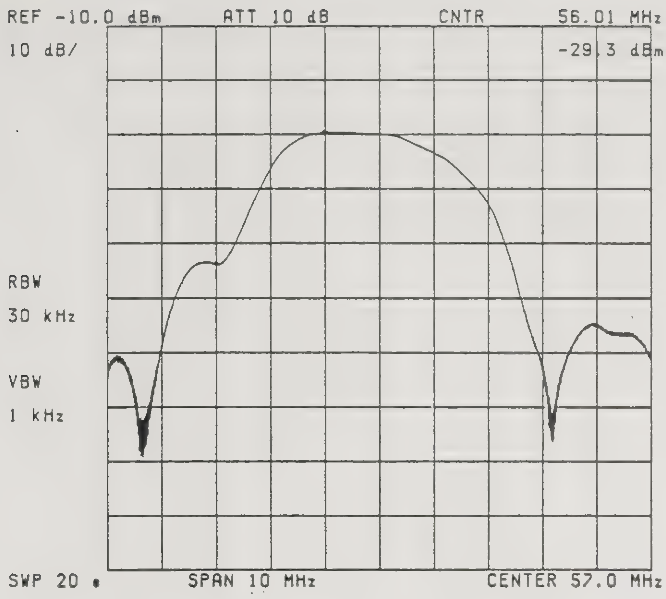


Fig. 6-8 Amplitude response of a filter

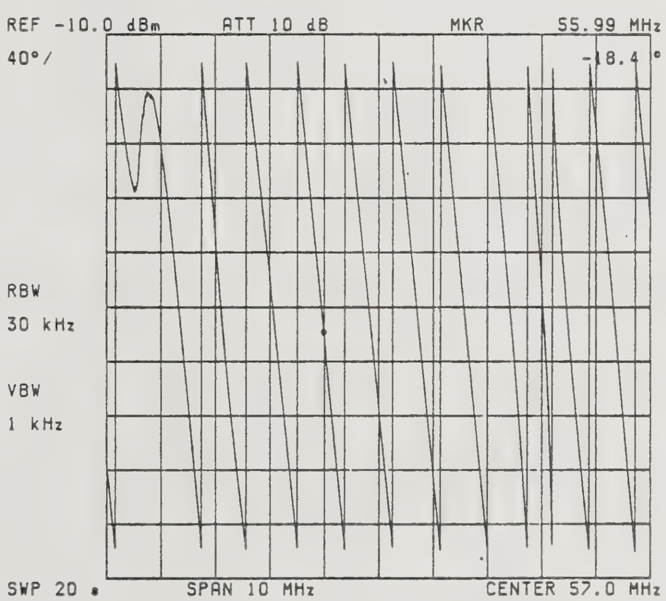


Fig. 6-9 Phase response of the filter

6-3-3. Phase Display Example

(1) Figure 6-10 shows a phase response display example for a saw filter covering a frequency range between 50 and 60 MHz. The example shows that the phase lag increases with frequency.

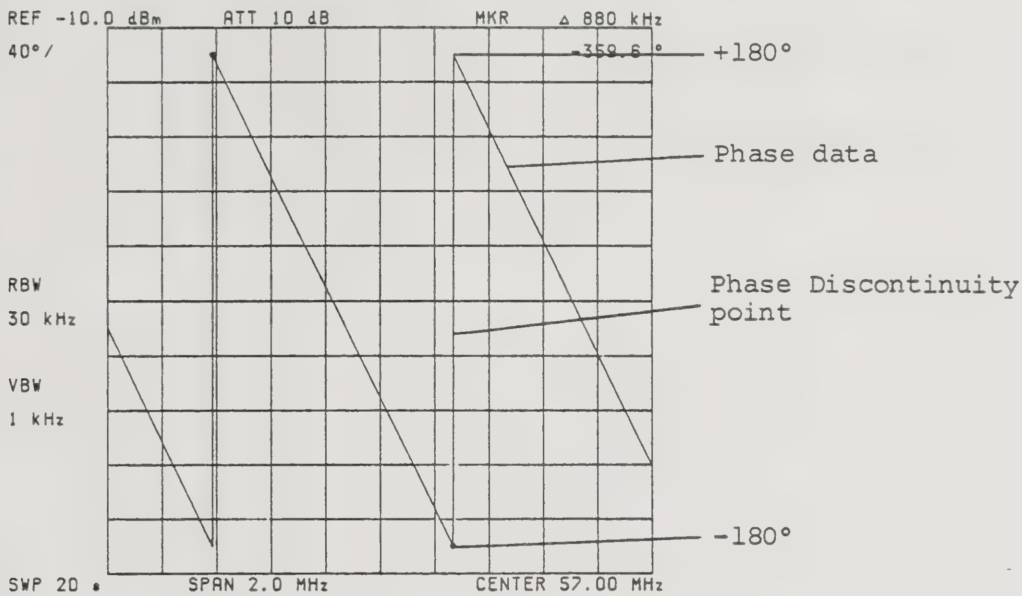


Fig. 6-10 Phase response display example

(2) The vertical dotted lines indicate discontinuity points on the response occurring at +180° and -180°.

(3) The center horizontal line (5 div. lines from the top graticule) indicates the zero phase.

(4) Numeric readouts indicate measurement conditions.

(5) This example shows the the filter has a phase lag of about 360° over about a 880 kHz frequency band. For more precise measurement, use the delta marker mode.

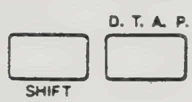
6-3-4. Usage of the Alternate Sweep

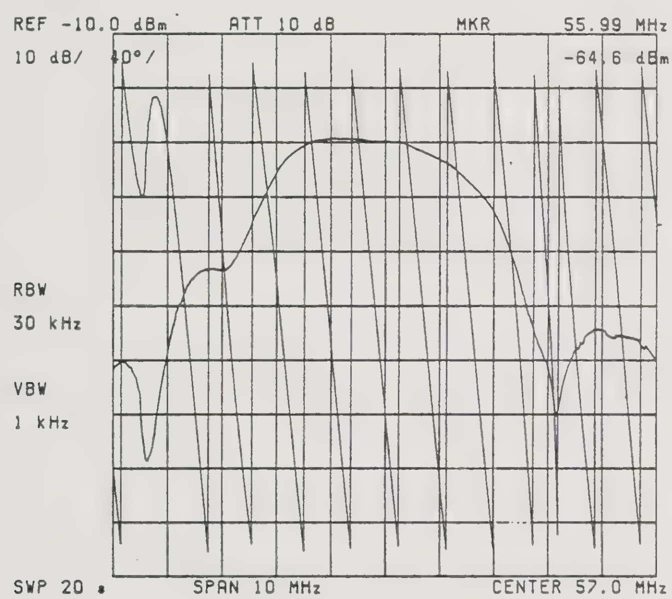
(1) Connect DUT to the instrument. Press the NORMAL key and measure the amplitude response of the DUT to set up necessary measurement conditions.

(2) According to the procedure in 6-3-2, adjust electrical length and determine phase resolution.

(3) Use the DATA knob to select the shortest sweep time which does not affect the phase data.

(4) To obtain the amplitude and phase responses at the same time on the display, press [SHIFT] [D. T. A. P.] H.





(5) To restore the normal measurement mode, press [SHIFT] [D. T. OFF] U. This will place one of trace memories A and B in the write mode and the other in the view mode. To clear unnecessary information, place one of the trace memories in the write mode, and the other in the blank mode.

SECTION 7
GROUP DELAY MEASUREMENT

7-1. GROUP DELAY MEASUREMENT PROCEDURE

This pharagraph describes group delay measurement procedure for amplifiers or filters.

(1) Connect the TRACKING GENERATOR OUTPUT to the input of the device under test (filter or amplifier) and connect the output of the device to the INPUT connector of the analyzer.

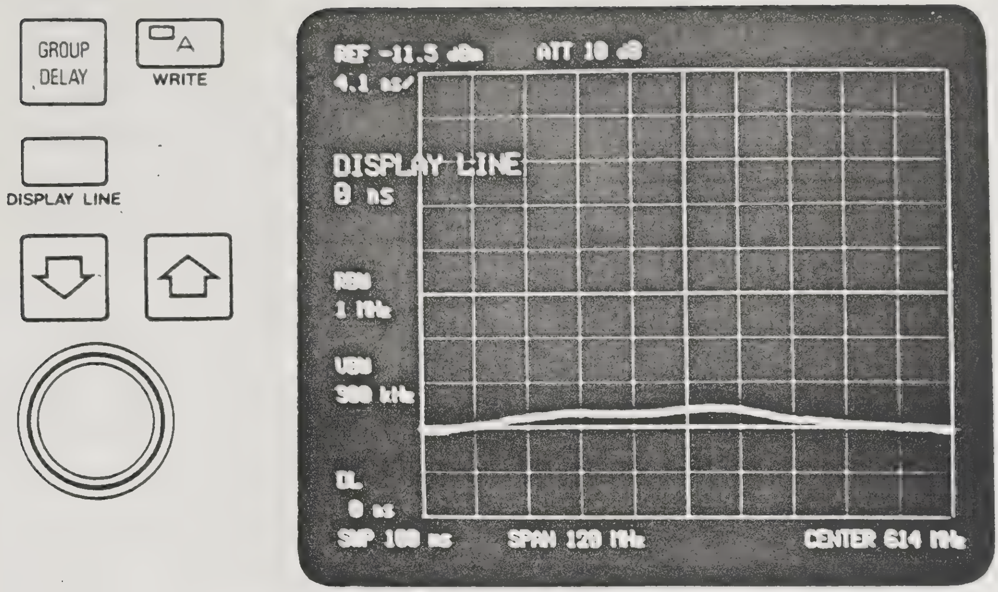
(2) Press the T.G. key to activate the tracking generator.

(3) Press the NORMAL key to measure the pass-band response of the device under test. According to the measurement result, select the appropriate T.G. level and INPUT ATT. level.

(4) The group delay response of the device under test can be observed by pressing the GROUP DELAY key. The display will also present delay time per vertical division as XX ns/ (or ps/ or ms/) in the top left display area.

(5) For more precise group delay measurement without the affect of the group delay of the measuring system itself, press the WRITE A key to write the group delay response of the measuring system into trace memory A.

(6) Then press the DISPLAY LINE key to activate a display line on the CRT, and use the DATA step keys and DATA knob to position the display line as close to the group delay response trace as possible.



(7) To clear the group delay of the measuring system press SHIFT (NORMALIZE) MHz dB sec.

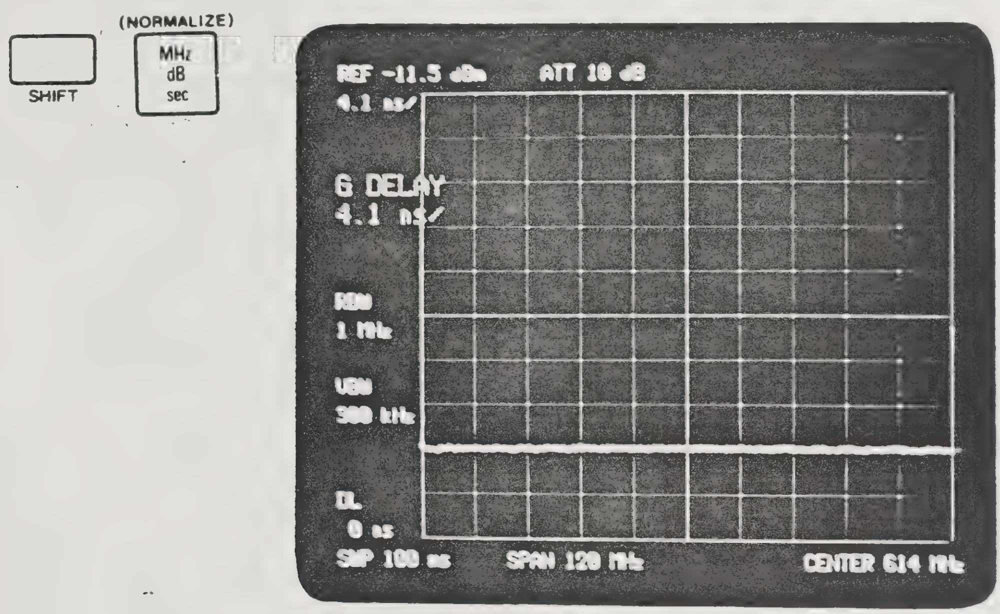


Fig. 7-1 Clearing the measurement system group delay

To cancel this group delay clear mode, press SHIFT OFF A−B → A.

(8) For still more precise measurement of group delay, use averaging. (See 4-14-1.)

After pressing the WRITE A key in step (5) above, press the SHIFT and k (AVG. ON) keys to initiate averaging.

When the programmed number of averagings is reached, follow steps

(6) and (7) above, then press the SHIFT and m (AVG. OFF) keys to disable averaging.

(9) To obtain a higher resolution in group delay measurement, press the GROUP DELAY key to activate resolution.
Group delay resolution can be increased by turning the DATA knob clockwise or operating the UP DATA step key. The DATA keyboard is not available for resolution control.
A too high resolution can cause overflow. If overflow occurs, press the G.D. OFFSET key to activate the electrical length and then adjust the electrical length with the DATA knob or DATA step keys to add offset to the group delay.

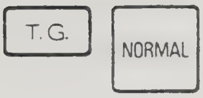
(10) During group delay measurement, press the PHASE key from time to time to check the phase response for overflow. Group delay will be indefinite on the overflow.
If phase rotation is observed, press the (G.D. OFFSET) key and adjust group delay offset with the DATA knob or DATA step key until phase rotation is eliminated.

(11) If high-resolution measurement suffers from poor signal-to-noise ratio, press the VIDEO BW key to narrow the video bandwidth. For group delay measurement, manually select a relatively long sweep time, do not use AUTO mode.

7-2. GROUP DELAY MEASUREMENT EXAMPLE

This provides a group delay measurement example using a filter as the device under test.

(1) Connect the TRACKING GENERATOR OUTPUT to the input of the device under test and connect the output of the device to the INPUT -1 of the analyzer.



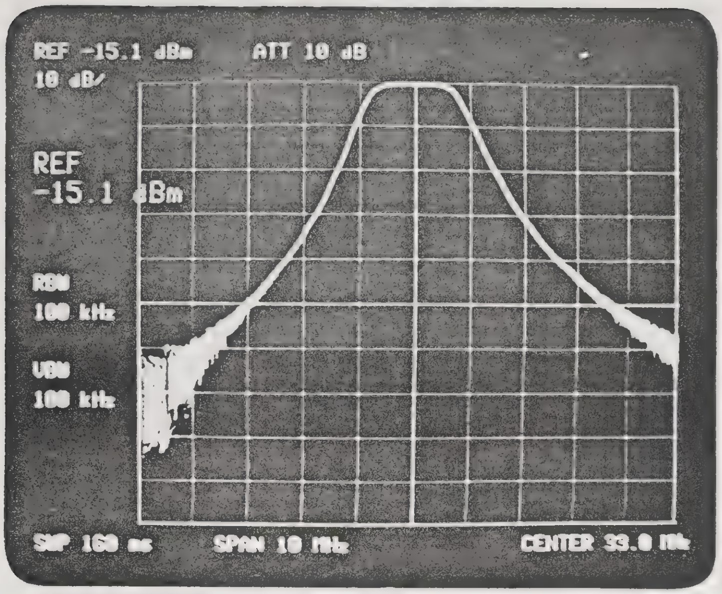


Fig. 7-2 Normal mode signal response

(2) Press the T.G. key to activate the tracking generator.

(3) Press the NORMAL key to measure the pass band response of the device under test. According to the measurement result select the appropriate T.G. level and INPUT ATT. level (Figure 7-2).

(4) Disconnect the device under test from the measuring setup and connect the input and output cables using an inline plug adapter to check the through frequency response.

(5) The through phase response can be observed by pressing the PHASE key (Figure 7-3).

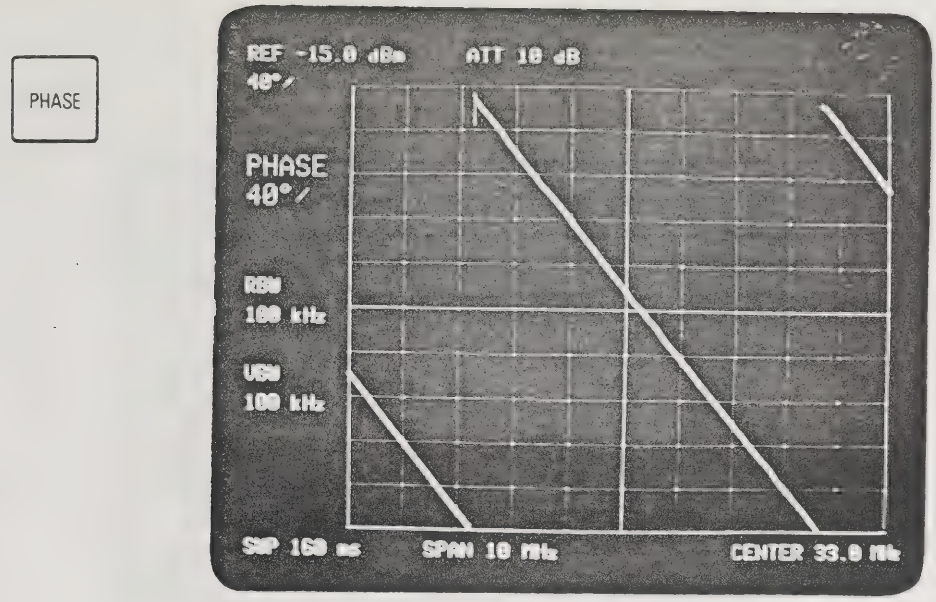


Fig. 7-3 Through phase response

(6) If phase rotation is observed, press the [G.D. OFFSET] key to activate the electrical length. Then adjust the phase response to flat with the DATA knob or DATA step keys (Figure 7-4).

If the AUTO key is pressed under these setup, group delay offset value is set to 0 ps. Consequently, when group delay value at marker point is to be displayed, the value adding subsequently entered group delay offset is displayed at the active function area on the left side of CRT.

(7) Next press the (PHASE OFFSET) key to enable entry of phase offset. Position the phase response trace to the center of the vertical graticule with the DATA knob or DATA step keys (Figure 7-5).

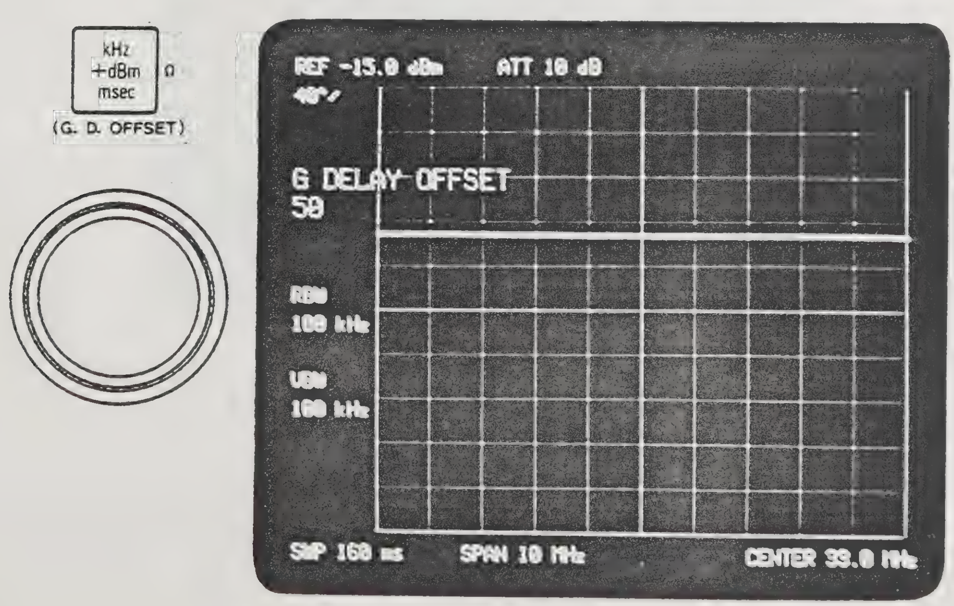


Fig. 7-4 Elimination of phase rotation

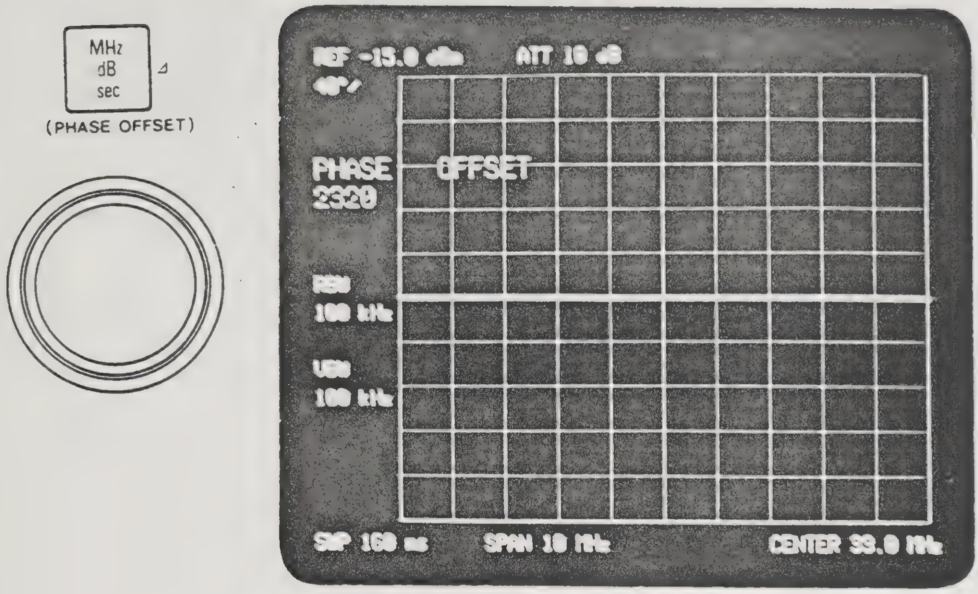


Fig. 7-5 Positioning the phase response trace
to the center of the vertical graticule

(8) Connect the device under test (filter) to the measuring setup to observe its phase response (Figure 7-6).

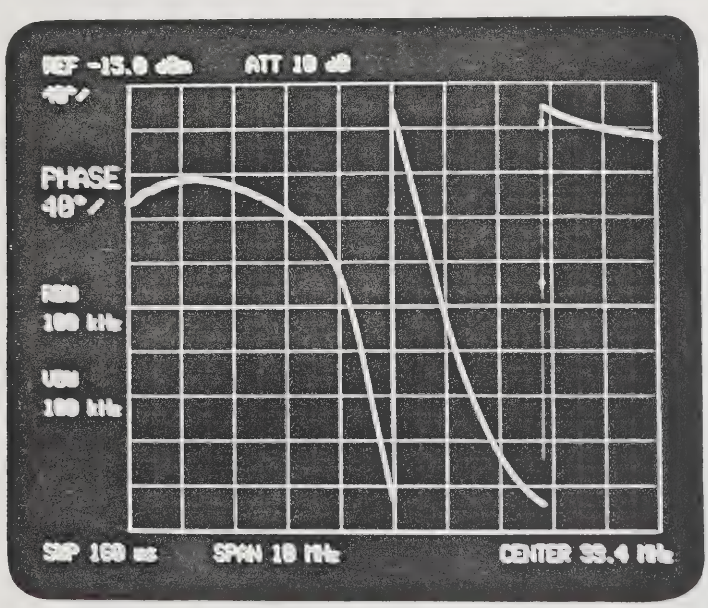


Fig. 7-6 Filter's phase response

(9) The group delay of the filter can be observed by pressing the GROUP DELAY key (Figure 7-7).

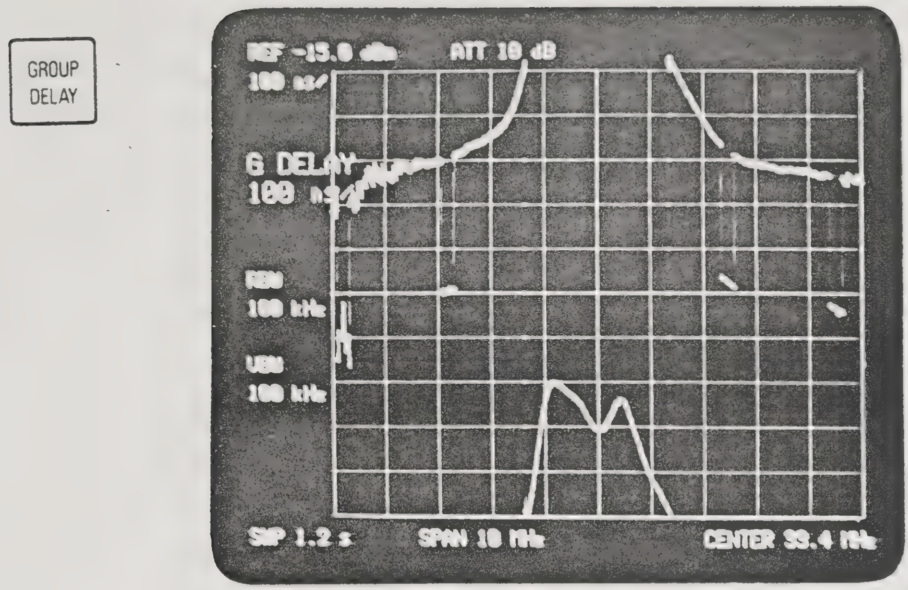


Fig. 7-7 Group delay measurement

(10) To obtain higher resolution for group delay measurement, resolution for phase measurement must be increased.
Press the PHASE key to activate phase. To increase phase resolution turn the DATA knob clockwise.
The phase readout (XX°/) in the active function display area will increase (Figure 7-8).

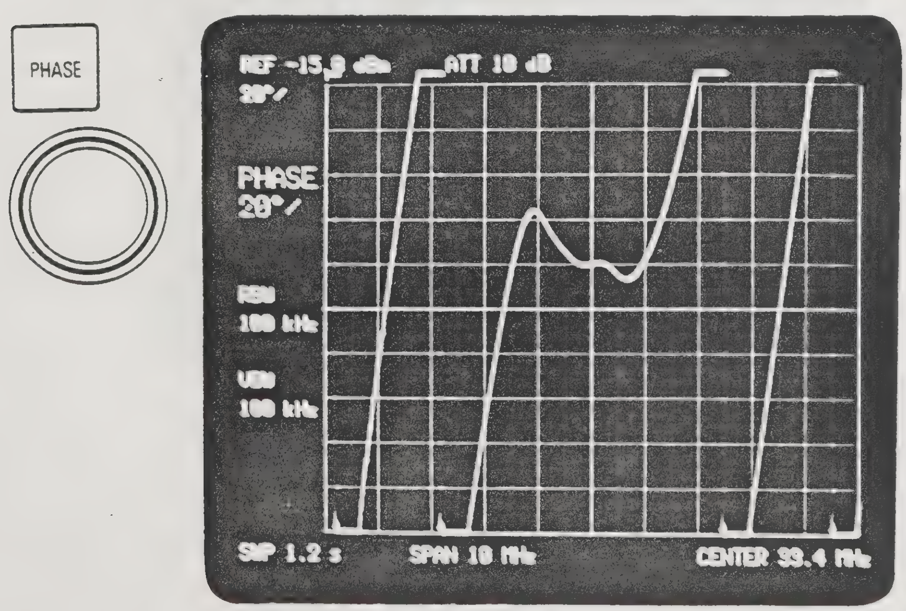


Fig. 7-8 Increasing phase resolution

(11) If phase overflow occurs in the pass band due to the increased phase resolution, press the (G.D. OFFSET) key to activate group delay offset. Then adjust the phase slope in the pass bandwidth with the DATA knob.

(12) The group delay of the device under test can be observed by pressing the GROUP DELAY key (Figure 7-9).

(13) For more precise group delay measurement, write the group delay of the through response into trace memory A at the same resolution (pages 7-1 and 7-2), bring the display line close to the through response trace, then press the SHIFT and MHz keys to eliminate the the group delay of the measuring system itself. Use of the averaging mode ((8) on page 7-2) will provide still more precise measurement.

(14) If a greater signal-to-noise ratio is desired, press the VIDEO BW key to narrow the video bandwidth. At this time press the SWEEP TIME key and select a relatively long sweep time.

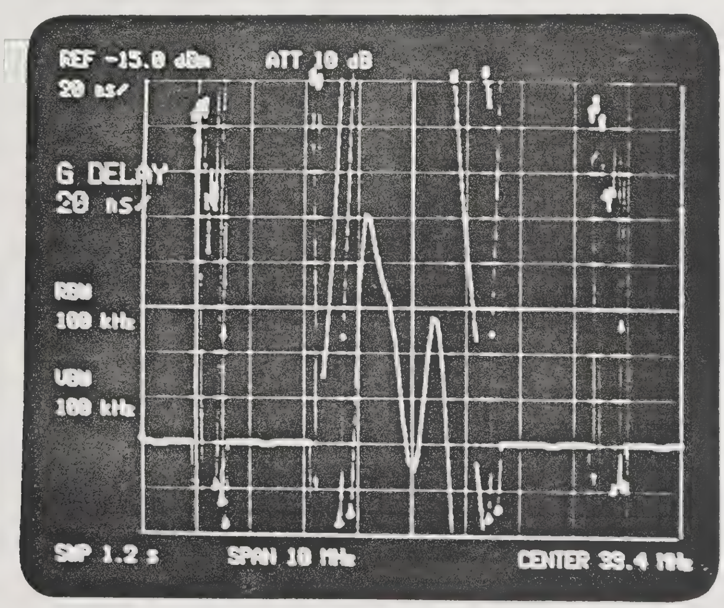


Fig. 7-9 Group delay measurement

A much greater signal-to-noise ratio will be obtained by selecting the averaging mode (press SHIFT and AVG. ON.) after connecting the device under test.

7-3. GROUP DELAY AND AMPLITUDE ALTERNATE SWEEP (SHIFT, M)

SHIFT,M performs group delay and amplitude measurements alternately. The results are written into memories B and A respectively and then transferred to the display simultaneously. The indicator lamps on the GROUP DELAY, NORMAL, WRITE A, and WRITE B keys will light.
To disable the alternate sweep mode press the SHIFT and ␣ keys.
The group delay and amplitude alternate sweep mode is usable together with the frequency response compensation mode (page 7-1) using the SHIFT and MHz keys. Followings are the measurement procedure example using a filter as the device under test.

(1) Connect the TRACKING GENERATOR OUTPUT to the device under test (filter or amplifier) and connect the output of the device to the INPUT-1 connector of the analyzer.

(2) Press the T.G. key to activate the tracking generator.

(3) Press the NORMAL key to measure the frequency response, and select appropriate T.G. level and INPUT ATT. level.

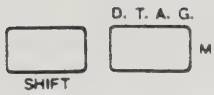
(4) Disconnect the device under test from the measuring setup and connect the input and output cables to check the through frequency response.

(5) Press the DISPLAY LINE key to activate display line on the CRT, and use the DATA step keys and DATA knob to position the display line as close to the through frequency response as possible.

(6) Press the SHIFT and M keys to specify group delay and amplitude alternate sweep mode.

(7) If the SHIFT and MHz keys are pressed at this time, both response traces of amplitude and group delay are normalized. In this case, amplitude response trace is normalized on the display line and group delay response trace is normalized on the second lowest graticule line of the CRT, respectively.

(8) Observe the device response traces of amplitude and group delay simultaneously.



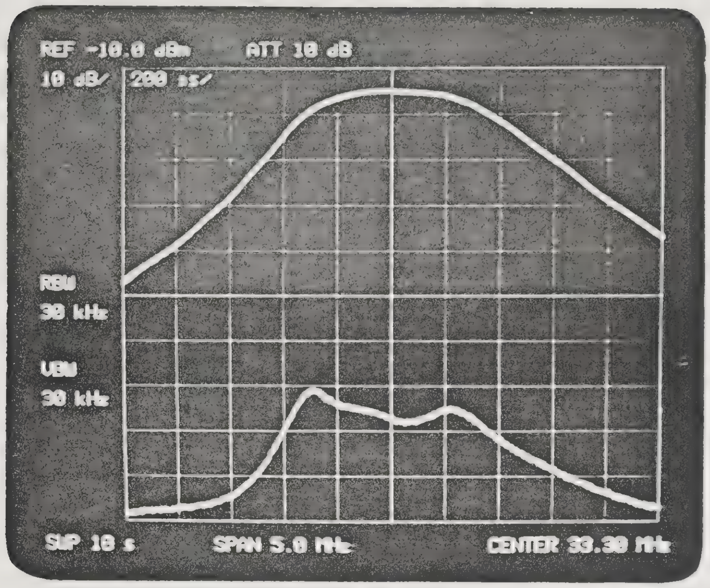


Fig. 7-10 Group delay and amplitude alternate sweep

7-4. APERTURE CONTROL

In general, a higher group delay resolution can cause lower signal-to-noise ratio. However, group delay resolution can be increased without sacrificing S/N ratio by increasing aperture. Aperture means $\varDelta F$ in the group delay equation $\varDelta\theta/\varDelta F$.

On the TR4172, aperture is normally set up as follows:

$$\varDelta F = \frac{24}{1000} \times \text{frequency span}$$

Constant 24/1000 in the above formula can be increased up to 192/1000 at four steps as follows:

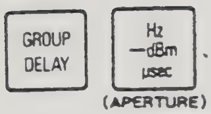
(1) Aperture control is possible only if group delay measurement resolution is not less than 4/(frequency span).
Press the GROUP DELAY (APERTURE) key to make sure that the current resolution meets the above condition.

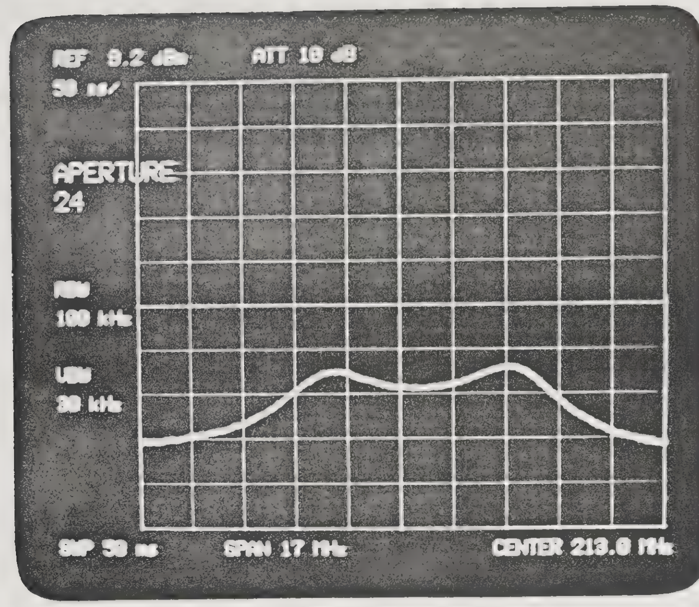
(2) Operation of the GROUP DELAY and Hz keys will activate the aperture. APERTURE 24 will be shown in the active function display area on the CRT to indicate that the current aperture is
$\frac{24}{1000}$ x (frequency span).
If the condition, resolution < 4/(frequency span), mentioned in item (1) above is not satisfied, the aperture will not be activated and hence "APERTURE 24" will not appear on the CRT.

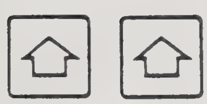
(3) Select the appropriate aperture from 24, 48, 96, or 192 with the DATA knob or DATA step keys. The numeric data keyboard is not usable for aperture selection.
Once aperture is increased, resolution can be increased without sacrificing S/N ratio.
For example, if the resolution is 100 ns/div. with the aperture 24/1000, the resolution can be increased to 50 ns/div. by changing the aperture to 48/1000.

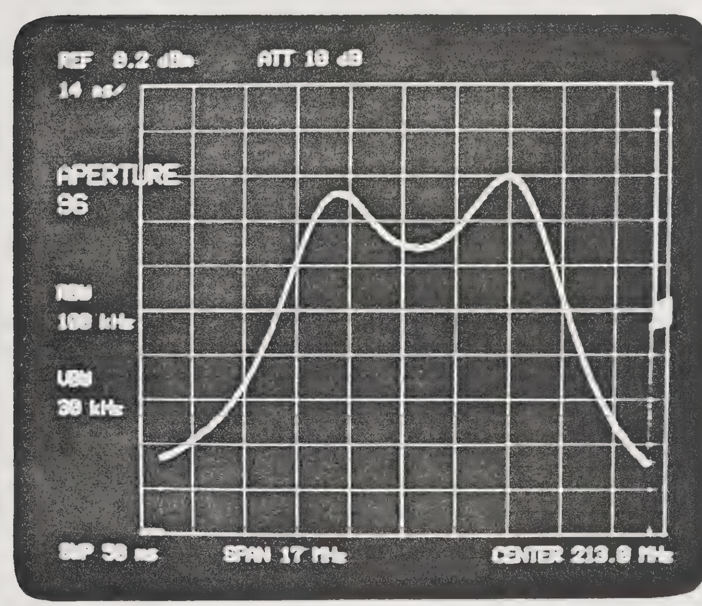
(4) As the aperture is increased, the effective range of the screen graticule is gradually reduced accordingly.
This is because (aperture/2 - 12) points out of 1001 points on the frequency axis are lost at both side ends of the graticule as aperture is increased.
When aperture is increased to 192, the effective range of the graticule is lessened by one division on each end of the graticule.

(5) Operation of the GROUP DELAY key will clear the active aperture mode and restore the active group-delay resolution mode.


GROUP
DELAY
Hz
—dBm
µsec
(APERTURE)

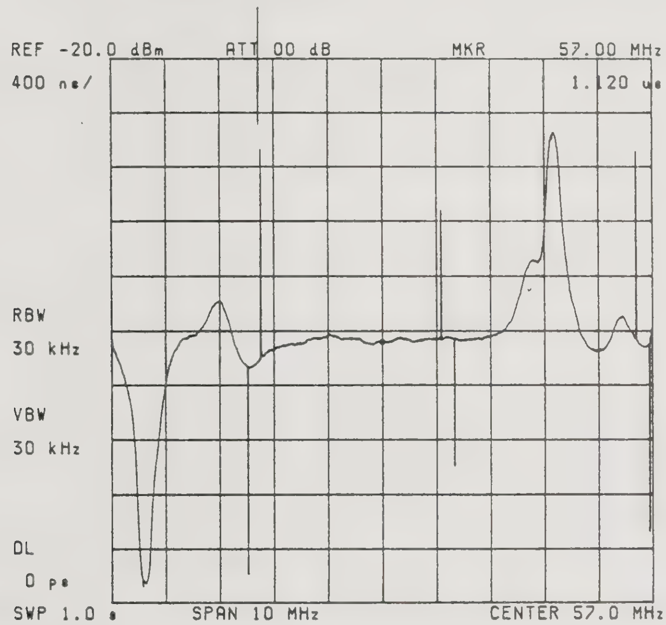

ATT 10 dB
APERTURE
24
SPAN 17 MHz
CENTER 213.0 MHz

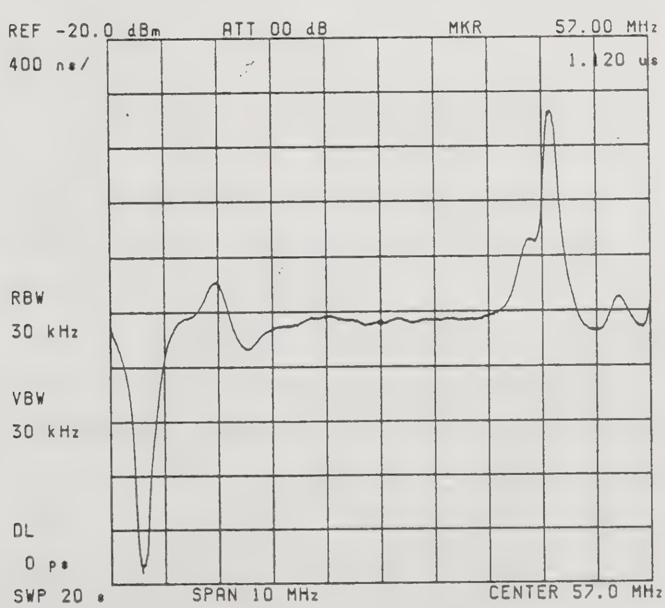



ATT 10 dB
APERTURE
96
SPAN 17 MHz
CENTER 213.0 MHz

During group delay measurement, the signal response trace on the display may produce spike noise as shown below.
To eliminate this noise, either of the following methods may be used:
(1) Select a sufficiently long sweep time.
(2) Perform electrical length correction to eliminate discontinuity of the phase response. Now the ripple of relative group delay is measured. Note that an absolute delay time cannot be measured.

Spike Noise





SECTION 8

ATTACHMENT TO GP-IB AND PROGRAMMING SUPPORT

8-1. INTRODUCTION

The TR4172 Spectrum Analyzer is attached to the GP-IB (specified in IEEE Standard 488-1978) via the GP-IB interface (standard supply). This section describes the specifications and operations of the GP-IB interface.

* GP-IB: General Purpose Interface Bus

8-2. GP-IB OVERVIEW

GP-IB enables interfacing of a measuring instrument with its controller or other peripheral devices through simple cabling (bus line).
Compared with other interfacing methods, GP-IB provides better expansibility, operability and compatibility with other products both electrically and mechanically, thus enabling construction of various grades of instrumentation systems through a single bus cabling.
In a GP-IB system, each system device on the bus must have its own address. Each device can be designated for one or two functions out of controller, talker, and listener functions. During system operation, only one talker may send data on the bus, while one of more listeners can receive the data.
The controller designates talker and listener addresses to cause the talker to send data to the listener or cause itself (talker) to send measurement condition data, etc. to the listener.
System devices are linked together with asynchronous, bidirectional bus (8 data lines), through which bit parallel, byte serial data is transferred. Due to its asynchronous nature, the bus permits attachment of both high-speed and low-speed devices at a time.
Data transferred between devices includes measurement data, measurement conditions (programs), or commands all in ASCII character format.
In addition to the 8 data lines, GP-IB includes three handshake lines to control asynchronous data flow between devices and five control lines to control information flow on the data bus.

The handshake lines transfer the following signals:

Data Valid (DAV): Indicates validity of transferred data.

Not Ready For Data (NRFD): Indicates data receive not ready state.

Not Data Accepted (NDAC): Indicates the data receive completion state.

The control lines transfer the following signals:

Attention (ATN): Used to discriminate address or command data on the data bus from other information.

Interface Clear (IFC): Clears the interface.

End or Identify (EOI): Indicates the end of data transfer.

Service Request (SRQ): Used by any device to request the controller for service.

Remote Enable (REN): Used to place a remote programmable device in the remote control mode.

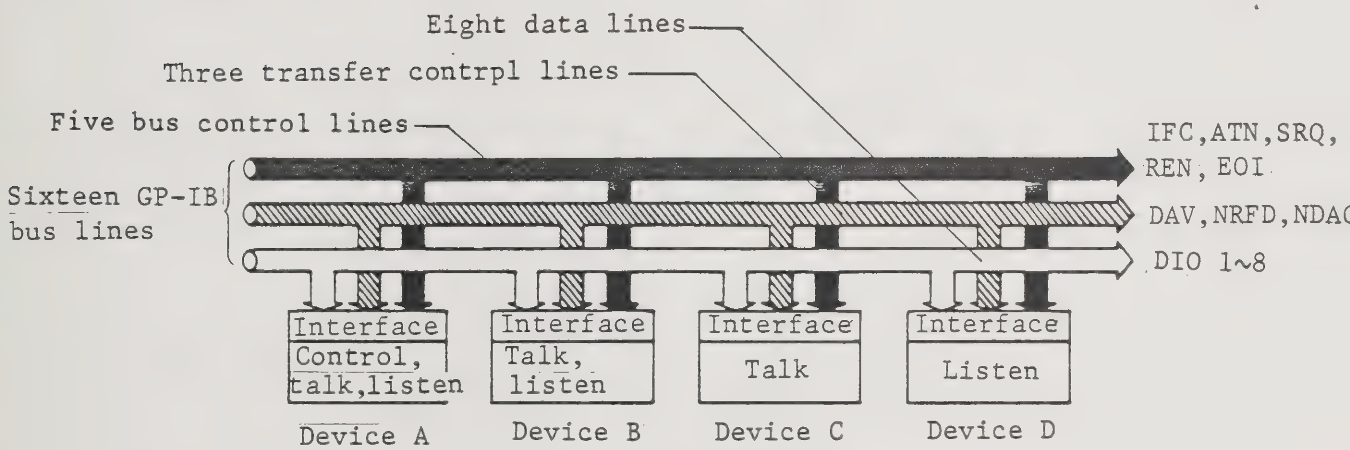


Fig. 8-1 Concept of GP-IB

8-3. SPECIFICATIONS

8-3-1. GP-IB Specifications

Standard: IEEE Standard 488-1978

Code: ASCII (binary code with packed format)

Logical levels: 0 (HIGH): +2.4 V or more

1 (LOW): +0.4 V or less

Signal line termination: 16 bus lines terminated as shown below:

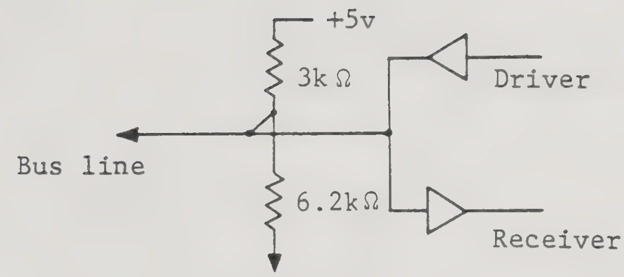


Fig. 8-2 Signal line termination

Driver: Open collector output

LOW output: +0.4 V or less, 48 mA

HIGH output: +2.4 V or more, -5.2 mA

Receiver: LOW at +0.6 V or less

HIGH at +2.0 V or more

Bus cable length: Total bus cable length should be less than 2 meters x (number of attached devices) and must not exceed 20 meters.

Address designation: Up to 31 talker and listener addresses can be designated with the rear ADDRESS switch. After address setting, operation of the MASTER RESET key is required.

Connector: 24 pin GP-IB connector

57-20240-D35A (Amphenor or equivalent)

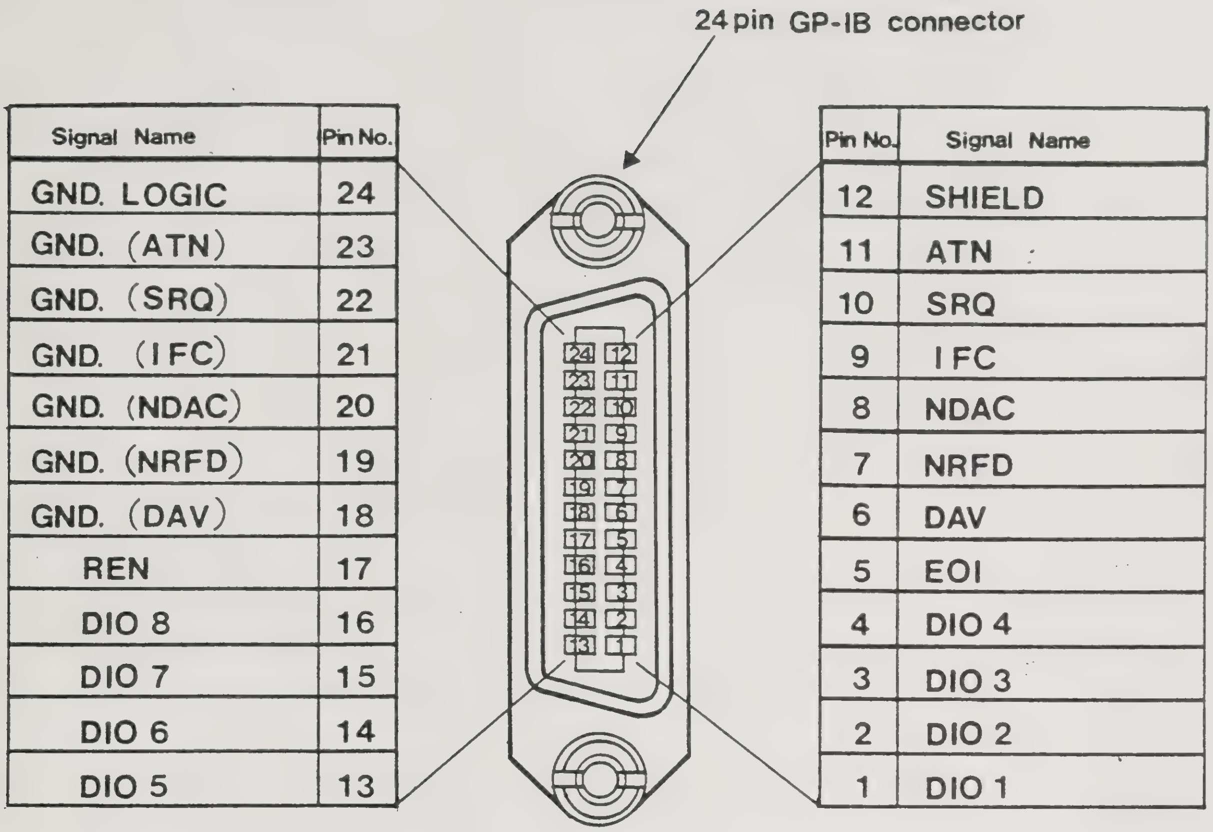


Fig. 8-3 GP-IB connector pin assignments

8-3-2. Interface Functions

Table 8-1 Interface functions

Code	Function
SH1	Source handshake
AH1	Accepter handshake
T6	Basic talker, serial poll Unaddressed to talk if addressed to listen.
L4	Basic listener function Unaddressed to listen if addressed to talk.
SR1	Service request
RL1	Remote function
PP0	No parallel poll function available.
DC0	No device clear function available.
DT0	No device trigger function available.
C0	No controller function available.

8-4. GP-IB HANDLING OPERATION

8-4-1. Device Attachment

The GP-IB system consists of multiple bus devices.

The following points should be noted:

(1) Before making interconnections between the TR4172, controller, and peripheral devices, check the status and operation of each device.

(2) The length of interconnecting and bus cables should be the necessary minimum. The total length of the bus cable should be 2 meters x (number of bus devices) and must not exceed 20 meters. The following standard bus cables are available from Takeda Riken:

TR4172 spectrum analyzer complies with FCC radiation specification. Use of the following connecting cables is suggested to construct a GP-IB system with the TR4172 spectrum analyzer.

Table 8-2 Standard bus cable (Accessories available)

Length	Name
0.5 m	408JE-1P5
1 m	408JE-101
2 m	408JE-102
4 m	408JE-104

(3) Bus cable connectors are of "piggy-back" type with both male and female plugs combined for each connector; stacked use of up to three connectors is possible.
After cable connectors are plugged to their mating receptacles, secure them with connector retention screws.

(4) Before powering each device, carefully check their power supply conditions, grounding and necessary settings. All devices attached to the bus must be turned on. If any one of the devices is left turned off, correct system operation will not be guaranteed.

8-5. TALKER FORMAT

(1) Reading a marker frequency in marker mode

```
␣MKR␣DD␣X␣DDDDDDD.DDD␣XXX CRLF
  |   |  |          |    |    |
  |   |  |          |    |    Block delimiter
  |   |  └Mode *1   |    |        ┌ MHz
  |   Marker No. *2 |    └─ Unit ┤ kHz
  Marker mode       |            └  Hz
                    |
                    └─ Data block (decimal point plus up to 10 digits
                       of numeric data)
```

(2) Reading a marker frequency in frequency counter mode

```
CNTR␣DD␣X␣DDDDDDD.DDD␣XXX CRLF
  |   |  |          |    |    |
  |   |  |          |    |    Block delimiter
  |   |  └Mode *1   |    |        ┌ MHz
  |   Marker No. *2 |    └─ Unit ┤ kHz
Frequency counter mode           └  Hz
and Tuned Amp. mode |
                    └─ Data block (decimal point plus up to 10 digits
                       of numeric data)
```

*1 Mode: "D" for delta mode
"Z" for zoom mode
"␣" for other marker modes

*2 Marker No.: ␣1 through 10. In the single marker mode, marker number is "␣␣" (space codes).

- Data block
  Data length is fixed to 25 bytes, and a decimal point is output to the position corresponding to that on the display.
  In either the marker mode or frequency counter mode, if the data block has nine or less valid digits, (10 - valid digits) of space codes are shifted to the top of the data block (preceding MKR or CNTR) before it is output.
- Block delimiter
  A block delimiter consists of a two byte code of CR and LF.
  Single line signal EOI is also output upon output of an LF code.

(3) Reading marker levels

␣DDD.D CRLF

Block delimiter

Data block (sign + decimal point + up to 4 digits of numeric data)

- Decimal point position corresponds to that on the display. In a read data stream, positive sign is represented by a space (␣) code and negative sign is represented by a minus (-) code. If the data block contains three or less valid digits, (4 - valid digits) of space codes are shifted to the top of the data block before it is output.

(4) Reading marker frequency data using the OA command

DDDDDDD.DDD E+D CRLF

Block delimiter

Exponent (E + one numeric character)

Mantissa (decimal point + up to 10 digits of numeric data)

- The decimal point position corresponds to that on the display.

Exponent: $E + 6 = 10^6$ (MHz)

$E + 3 = 10^3$ (kHz)

$E + 0 = 10^0$ (Hz)

8-6. PROGRAMMING SUPPORT

The TR4172 Spectrum Analyzer permits remote control of all front panel functions, ranges, and settings from the GP-IB controller. This section provides some programming examples for remote control using the HP9825A as the controller.

<Example 1>

Setting center frequency at 230 MHz, frequency span at 200 kHz, and video bandwidth at 30 MHz

wrt 701, "CF230MZ SP200KZ VB30HZ"

Addresses controller to talk.

GP-IB specification

TR4172's device address

Center frequency command

Center frequency setting

Execution of the above statement can be initiated by operating the EXECUTE key.

The header contains a command, the listing of which is shown below:

Table 8-3 Programming Codes

Item		Code		Initially selected
FUNCTION		CF	CENT. FREQ.	
		SP	FREQ. SPAN	
		RE	REF. LEVEL	
		SW	SWEEP TIME	
		AS	SWEEP TIME AUTO	o
		RB	RES. BW	
		BA	RES. BW AUTO	o
		VB	VIDEO BW	
		VA	VIDEO BW AUTO	o
		CS	CF STEP SIZE	
		CA	CF STEP SIZE AUTO	o
DATA		0-9	0-9	
		•	•	
		MZ	MHz	
		KZ	KHz	
		HZ	Hz	
		DP	+dBm	
		DM	-dBm	
		SC	sec	
		MS	msec	
		UP	⇧	
		DN	⇩	
		HO	HOLD	
DATA knob	Clockwise	CU	COARSE UP	
		MU	MEDIUM UP	
		FU	FINE UP	
	Counter-clockwise	CD	COARSE DOWN	
		MD	MEDIUM DOWN	
		FD	FINE DOWN	

Item	Code		Initially selected
TRIGGER	IN	INT.	o
	LI	LINE	
	EX	EXT.	
	VT	VIDEO	
	SI	SINGLE	
SAVE	SA	SAVE	
	RC	RECALL	
TRACE	AW	WRITE A	o
	BW	WRITE B	
	AV	VIEW A	
	BV	VIEW B	
	CH	A ⇄ B	
	BD	B-DL → B	
	AB	A-B → A	
	BB	B → B'	
	AZ	VIEW A'	
	BZ	VIEW B'	
MARKER	MK	MARKER	
	MO	OFF	
	MT	Δ	
	PS	PEAK SEARCH	
	ZØ	ZOOM	
	MC	MKR → CF	
	SG	SIGNAL TRACK	
	MP	MKR/Δ → STEP SIZE	
	CN	FREQ. CNTR	
	MR	MKR → REF.	
INPUT MODE	GD	GROUP DELAY	
	PH	PHASE	
	NO	NORMAL	o
	PR	INPUT-2	
	DC	INPUT-1 DC	
	AC	INPUT-1 AC	o
	AT	INPUT ATT.	
	TA	INPUT ATT. AUTO	o

Item	Code		Initially selected
T. G. MODE	TG	T. G.	
	TL	T. G. LEVEL	
Service	SQ	Service Request Enable	
Request	SR	Service Request Disable	o
	DL	DISPLAY LINE	
	LA	LABEL	
	SH	SHIFT	
	LC	LCL	
	IP	MASTER RESET	
	MF	MARKER FREQ. OUTPUT	
	ML	MARKER LEVEL OUTPUT	
	RD	MEMORY READ	
	DR	DATA READ END, STATUS BYTE RESET	
	OA	OUTPUT ACTIVE DATA	
	LD	LOAD MEMORY	
	TI	TRACE INPUT	
	TO	TRACE OUTPUT	

Each command is shown on the panel in Figure 8-4. These characters should be specified in the order of the corresponding key operation.
Use MZ and HZ for the unit of dB and sec, respectively.
Use MZ and KZ for (PHASE OFFSET) and (GROUP DELAY OFFSET), respectively.
It is also possible to specify clockwise and counter-clockwise rotations of the DATA knob. Course, medium and fine control of the DATA knob can be specified by codes CF, MF, and FU respectively for clockwise rotation, and by codes CD, MD, and FD respectively for counterclockwise rotation.
The three degrees of DATA knob control are available for the following functions:
CENT. FREQ., FREQ. SPAN, REF. LEVEL, MARKER, DISPLAY LINE,
GROUP DELAY OFFSET, and PHASE OFFSET
<Example 3>
Activating a display line (DL) and a marker (MK), and setting the reference level (RE) at -3.2 dBm (DM for -dBm)
wrt 701, "DLMKRE3.2DM"

8-7. SERVICE REQUEST

A service request is sent when measurement or averaging is completed (ie, averaging number reaches the preset number.)

wrt 701, "SQ" enables service request.

wrt 701, "SR" disables service request.

	8	7	6	5	4	3	2	1
STATUS BYTE		1			1	1		

Bit 3 → Measurement end

Bit 4 → Averaging end

Bit 3: Set to 1 when measurement is completed.

Bit 4: Set to 1 upon the end of averaging.
Remains 0 during averaging.

Bit 7: Set to 1 when bit 3 or 4 is set to 1. This bit remains at 1 until a status byte is read by the controller.

When service request is enabled, the controller reads data from the device in request. Upon the end of data read, the controller writes "DR" to initiate the next measurement.

<Example 4>

```
0: wrt 701, "SQ"            Enable service request.
1: oni 7, "int"             Jump to "int" if interrupt (service
                            request) occurs.
2: eir 7                    Enable the controller for interrupt.
3: gto 1
10: "int": rds (701)→A      Read status byte.
11: wrt 701, "DR"           Start sweep. Status byte reset
12: prt A                   Print A.
13: iret                    Return to main program.
```

The following explains examples of single sweep using the 

key:

For single sweep, insert "SHLASW" before "DR" as shown in Example 4'.

[Example 4']

```
0:   wrt 701, "IP SW 2SC"······ Master resetting.  The sweep time is set to 2
                                seconds.
1:   wrt 701, "SQSI"··········· Service request enable state.  The trigger is
                                set in the single sweep mode.
2:   wrt 701, "MK ML"·········· The marker and marker level reading modes are
                                set.
3:   oni 7, "int" ············· If an interrupt occurs, control jumps to
                                "int."
4:   eir 7
5:   gto 3
6:   "int": rds(701)→A
7:   red 701, B ··············· The marker level is stored in memory B.
8:   dsp B
9:   wrt 701, "SHLASW" ········ Resetting sweep
10:  wrt 701, "DR" ············ Resetting the status byte
11:  wrt 701, "SI" ············ Sweep operation is performed once.
12:  iret
13:  end
* 5308
```

8-8. READING MARKER FREQUENCY AND LEVEL

<Example 5>

wrt 701, "MF"

red 701, A$

In this example marker frequency is read in the same format as the marker frequency readout on the display.

A marker level can also be read in much the same way:

Set the dimension of A$ to more than 24, because 24 data of marker frequency are sent out. Blank (␣) may be sent out at the head of the data.

When reading a marker frequency as a number with no engineering unit, use the OA command as described in the following paragraph.

<Example 6>

wrt 701, "ML"

red 701, A$

The marker level is read as a numeric data with no unit.

Therefore, it may also be read by specifying:

red 701, A

Since 8 marker level data are sent out, the dimension (dim) for A$ or A should be set up at 8 or more. For phase measurement, however, it should be set up to 9 or more.

Send data is always preceded by a blank code.

When it is desired to read the unit for marker level as part of character strings, it should be entered in the form of character string variable as shown in example 7. In this case, the dim for A$ must be set up to 24 or more.

<Example 7>

1: dim A$ [24]

2: wrt 701, "MF" ← Specify not "ML" but "MF".

3: wrt 701, "LD73C40E0099DC

- LD73C4 → Read instruction for marker level and unit
- 0E00 → Number of data to be read
- 99DC → Read start address

4: red 701, A$

In the example 7, marker level and unit are entered into A$ in the form of a character string.
The 0E00 specifies the number of data to be read, and 99DC specifies the read start address (both hex code). In this example, 0E is the low order digits while 00 is the high order digits. Therefore, the actual number and address are 000E and DC99 respectively.

8-9. SETUP DATA READ (OA)

Center frequency, frequency span, resolution bandwidth, marker frequency, and some other data which are shown in the active function display area on the screen, can be read in the form of numeric data without unit by using the OA (Output Active) command.
With the OA command, the active data which is currently shown in the active display area on the screen is read. For example, if resolution bandwidth is 300 kHz, it is read into "A" in the following statement in the form of 300000:

```
wrt 701, "RBOA"
red 701, A
```

The "RB" preceding the "OA" in the above statement is necessary to activate resolution bandwidth.
If data is to be read in the exponent form, use the A$ command.
The data given in the above example is read in the form of 300E3 by the following statement:

```
red 701, A$
```

When a marker is activated, the frequency and level at the marker are shown in the active display area on the screen as follows:

MARKER 1
50 MHz
-10 dBm

However, the OA command reads only the frequency data. In general, when two data are activated at the same time, the OA command reads only the upper data in the active display area.

If this OA command is followed by an LD73C6 which is followed by a screen address as shown in Figure 8-5, any information on the screen can be read out with its engineering unit. For example, the reference level or marker level can be read with unit V, mV, or µV when the vertical scale is set up in the linear mode, or a video bandwidth value can be read out without making it active. Specify the screen address for the information to be read following OALD73C6. The marker level and video bandwidth are assigned addresses DC9C and DDA0, respectively, as shown in Figures 8-4 and 8-5.

<Example 7'> Reading a video bandwidth with its engineering unit:

```
wrt 701, "OALD73C6A0DD"
red 701, A
```

8-10. VERTICAL SCALE READ (dB/DIV.)

The setup for vertical scale factor (dB/DIV.) can be read into "OA" and "LD73C50870DC" as a numerical variable. Number 08 of "LD73C50870DC" denotes the number of data to be read, while DC70 denotes the first character location address of the display where XX dB/ is displayed. The vertical scale factor setup can be read into "MF" and "LD73C670" as a character string variable. Example 8 reads scale factor 10 dB/DIV. as a numerical variable, and Example 9 reads scale factor 10 dB/DIV. as a character string variable.

<Example 8>

Reading 10 dB/DIV. as a numerical variable:

```
1: dim A [8] ←— Set to 8 or more.
2: wrt 701, "OA" ←— Read as a numerical variable
3: wrt 701, "LD73C50870DC" ←— Read dB/DIV.
4: red 701, A[1] ←— "10" is read into register A.
```

<Example 9> Reading 10 dB/DIV. as a character string variable:

```
1: dim A$ [24] ←— Set to 24 or more.
2: wrt 701, "MF" ←— Read as a character string variable.
3: wrt 701, "LD73C670" ←— Read dB/DIV.
4: red 701, A$ ←— "10 dB/DIV." is read into register A$.
```

8-11. DISPLAYED DATA READ/WRITE

All internal memories in the TR4172 are accessible for reading from an external controller, and all internal RAMs of the TR4172 are accessible for writing from an external controller. This read/write capability allows for more sophisticated control of the instrument.

8-11-1. Displayed Data Read

Displayed data (amplitudes at each of the 1001 points on the frequency graticule) can be read with the RD (Read Memory) command. To do this, specify the read start address and the byte count of the data to be read in hex code.
Trace memory A has address allocations of C018 through C7E8, while trace memory B has that of C818 through CFE8. Each data has two byte length, and the low order byte is first read, followed by the high order byte. When 150 points of data are to be read starting from the first (leftmost) location of memory A, a register dimension of 150 x 2 = 300 = hex 12C is required as each data occupies two byte length (see example 10).
If contents of trace memory A and A', or B and B' are displayed simultaneously, two byte length data of trace memory A and A', or B and B' are stored from C018 or C818 of address allocations. For example, memory data A is stored at C018 and C019, memory data A' is stored at C01A and C01B, memory data A is stored at C01C and C01D, and memory data A' is stored at C01E and C01F.

<Example 10>

```
wrt 701, "RDC018012C"
            |  |   |
            |  |   └──Byte count of data to be read (hex)
            |  └──Start address
            └──Read command
```

The displayed data is read into register A$ in ASCII format by specifying:
red 701, A$
In this case, the dimension of register A$ must be present to more than 4 times the number of data to be read. For the above example, the register dimension must be preset to 150 x 4 = 600 or more.

Display data is stored in addresses 0 through 1001 of the trace memory. The low byte of each display data occupies even addresses, whereas the high order byte of each display data occupies odd addresses. In even addresses, 8 bit data is valid, while in odd addresses, only 2 bit data is valid and the most significant 6 bits of data in odd addresses are invalid. When read, the most significant 4 bits of odd-address data is modified into F.

A read example for two data is shown in example 11.

<Example 11>

```
wrt 701, "RDCD180004"
red 701, A$
Data read into A$ ---- 3AF1 39F1
                       |  |
                       |  └──── High order (F is invalid)
                       └─────── Low order byte
```

In this example, the actual data read into register A$ are $13A_{16}$ = 314 and 139_{16} = 313. To read data in decimal form, use the TO command to be described in the following paragraph.

Data can be read in the binary mode by inserting an LDBEB501 command. In this case, two-byte data is output in the order of high-order and low-order bytes.

<Example 11'>

```
10   OUTPUT 701; "RDC0180004"
20   DIM A$[20]
30   OUTPUT 701; "LDBEB501"
40   ENTER 701 USING "%,#%K"; A$
50   DISP A$
60   END
```

8-11-2. Display Data Read in Decimal Form

Display data in trace memory A or B can be read in the decimal form with the TO (Trace Output) command.

<Example 12>

```
1: wrt 701, "RDC0180040" ——→ Read data from address C018 of trace
                              memory A.
2: wrt 701, "TO" ———————————→ Decimal data read command
3: red 701, C ——————————————→ Data in addresses C018 and C019 is read
                              into memory C in decimal form.
4: red 701, C ——————————————→ Data in addresses C01A and
                              C01B is read into memory C in decimal
                              form.
```

If contents of trace memory A and A' are displayed simultaneously, the data read out by "3:" are stored in memory A and the data read out by "4:" are stored in memory A'.

8-11-3. Data Write to Display

Data can be written into trace memories (and hence display) with the LD (Load Memory) command. With this feature, measurement information read into the controller can be again shown on the display after it is subject to necessary operations or modifications in the controller. Upper or lower limit data can also be written onto the display.

<Example 13>

```
wrt 701, "LDC90023FAB31C"
          │ └──→ Write start address
          └──→ Write command
```

In this example, "LD" is the WRITE command, and "C900" gives the write start address. Data of 23, FA, B3, and 1C are sequentially written into addresses C900, C901, C902, and C903 respectively. When writing data in the decimal form, see the following paragraph.

8-11-4. Data Write in Decimal Form

With the TI (Trace Input) command, data can be written onto the display in the decimal form.

<Example 14>

```
1: wrt 701, "RDC0180040" ——→ Write stat address (address C018 on
                              memory A)
                          └──→ Must always be 0040.
2: wrt 701 "TI" ———————————→ Decimal data write command
3: 100 ——→ A
4: wrt 701, A ——→ Write A (100 in decimal).
5: A + 100 ——→ A ——→ (A: number between 0 and 1024)
6: wrt 701, A ——→ Write A + 100 = 200 into address C01A.
```

The second "wrt 701, A" written on line 6 in the above example causes decimal data A to be written into addresses C01A and C01B on the trace memory. Each time "wrt 701, A" is specified subsequently, memory addresses are automatically incremented. The top address of memory B is C818. Therefore, to write data begining from the top address of memory B, specify wrt 701, "RDC8180040".

<Example 15>

Example is to draw an up-going diagonal line on the display.

```
0: wrt 701, "AV"
1: wrt 701, "RDC0180040"
2: wrt 701, "TI"
3: 0 ——→ A
4: for I = 1 to 1000
5: wrt 701, A
6: A + 1 ——→ A
7: next I
```

8-12. PROGRAMMING EXAMPLES

This section presents two examples of automatic measurement programming for the TR4172 under GP-IB control.
In these examples, the TR4172 is addressed to "708".

8-12-1. Programming Example 1

The paragraph presents a programming example to determine the 3 dB down bandwidth and peak frequency of a 184 MHz band-pass filter.

The following program activates a marker, performs peak search to position the peak response to the center of the screen, controls the marker to determine the 3 dB down point on the left-hand side of the peak, then moves the marker to determine the other 3 dB point on the right-hand side of the peak. Programming may be done in the same procedure as manual operations. The following example uses Hewlette-Packard Model 9825A for the controller.

<Example 16>

```
0: "3db band width measure":dim A$[25];dim B[20]
1: wrt 708,"IP CF184MZ SP10MZ TG"
2: wait 200;wrt 708,"PS MC"
3: wait 200;wrt 708,"MR MF";wait 200
4: red 708,A$;wrt 708,"MT"
5: wait 50;wrt 708,"ML CD"
6: "mls":red 708,B
7: if B<-3;gto "next1"
8: wrt 708,"FD";gto "mls"
9: "next1":wrt 708,"MT CU CU"
10: "mls2":wrt 708,"FU";red 708,B
11: if B<0;gto "next2"
12: gto "mls2"
13: "next2":wrt 708,"OA";red 708,B
14: B/1000000→B
15: prt "3db band",B,"MHZ"
16: dsp A$
17: end
*14504
```

Notes) 1: Center frequency 184 MHz, span 10 MHz, Tracking generator ON

2: Peak search, Marker → CF

3: MKR → REF., marker frequency output

4: Marker delta (Δ)

5: Marker level output, DATA knob course counterclockwise adjustment

8: Fine counterclockwise adjustment

9: Marker delta, course clockwise rotation

10: Fine clockwise rotation

13: Active data (marker delta frequency difference) output

8-12-2. Programming Example 2

This paragraph shows a programming example to measure the 50 MHz reference frequency of the TR4172 and its second harmonic frequency and level.

<Example 17>

```
 10 ! LEVEL AND FREQ.MEASURE !
 20 OUTPUT 708 ;"IP CF 50MZ SP 5
    MZ" @ WAIT 200
 30 OUTPUT 708 ;"PS CN MF" @ DIM
     A$[26]
 40 WAIT 200
 50 ENTER 708 ; A$
 60 PRINT A$
 70 OUTPUT 708 ;"CF 100MZ SP 100
    KZ"
 80 WAIT 200 @ OUTPUT 708 ;"PS"
 90 WAIT 100 @ ENTER 708 ; A$
100 PRINT A$
110 OUTPUT 708 ;"ML" @ ENTER 708
     ; B
120 IMAGE "2ND LEVEL",1X,DDDDDD.
    DD,1X,"dBm"
130 PRINT USING 100 ; B
140 END
```

Notes) 20: Center frequency 50 MHz, span 5 MHz

30: PEAK SEARCH, FREQ. CNTR and marker frequency output

50: Center frequency 100 MHz, span 100 MHz

60: PEAK SEARCH

90: Marker level output

8-13. CHARACTER WRITE TO DISPLAY

Characters can be written onto the display from the controller. Character locations on the display and their addresses are shown in Figures 8-4 and 8-5 respectively. Writable character codes are listed in Table 8-4.

For example, characters "REF" are written in addresses DC38, DC39, and DC3A by using codes 12, 05, and 06. To replace these characters with another set of characters "ABW", specify as follows:

wrt 701, "LDDC38010217"

To expand character "A" on the display, use code 41 instead of 01 by referring to the Large column in Table 8-4.

When making a line feed operation after writing certain characters on the display, use the codes listed in the End column. If code 81 is specified instead of 01 in the above example, characters "BW" are written from the first character location of a new line after "A" is written on the preceding line. It should be noted here that characters "ATT." or "MKR" which were on the same line as the REF. are also repositioned to the next line.

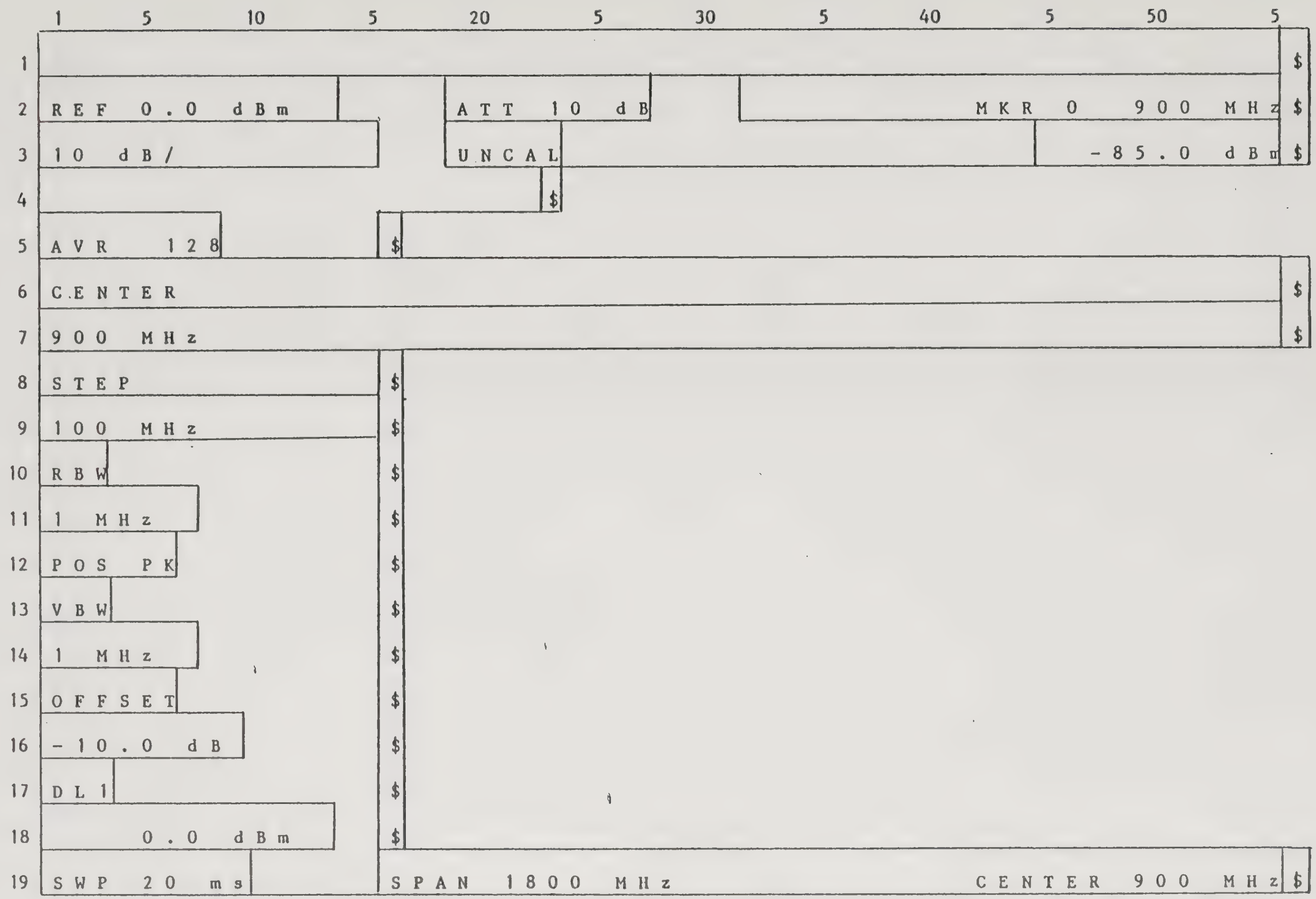


Fig. 8-4 TR4172 Character Locations

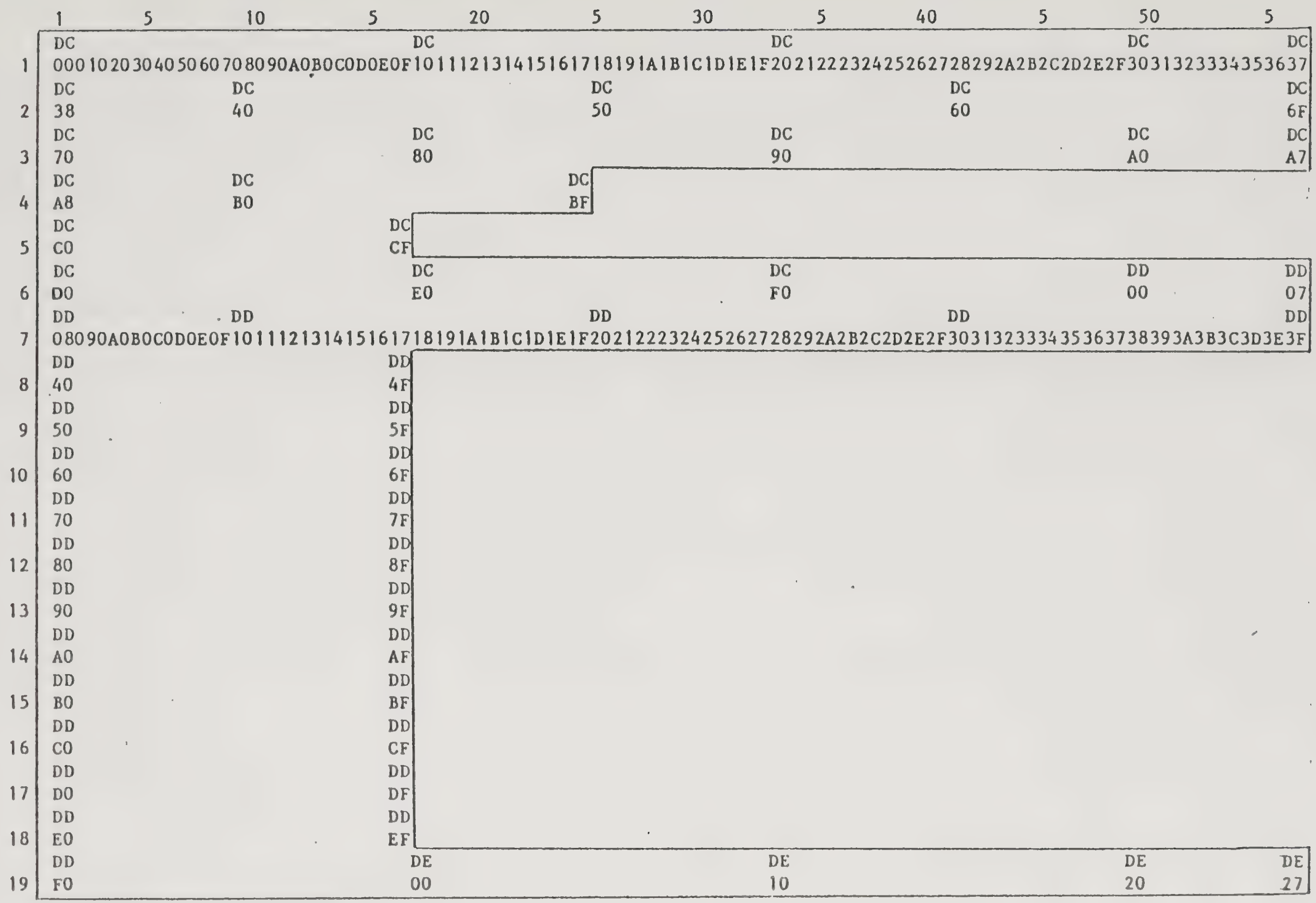


Fig. 8-5 TR4172 Display Addresses

Table 8-4 TR4172 alphanumeric character set vs. hex codes

	Normal	Large	End
p	00	40	80
A	01	41	81
B	02	42	82
C	03	43	83
D	04	44	84
E	05	45	85
F	06	46	86
G	07	47	87
H	08	48	88
I	09	49	89
J	0A	4A	8A
K	0B	4B	8B
L	0C	4C	8C
M	0D	4D	8D
N	0E	4E	8E
O	0F	4F	8F
P	10	50	90
Q	11	51	91
R	12	52	92
S	13	53	93
T	14	54	94
U	15	55	95
V	16	56	96
W	17	57	97
X	18	58	98
Y	19	59	99
Z	1A	5A	9A
_	1B	5B	9B
Ω	1C	5C	9C
k	1D	5D	9D
Δ	1E	5E	9E
m	1F	5F	9F

	Normal	Large	End
blank	20	60	A0
n	21	61	A1
'	22	62	A2
#	23	63	A3
j	24	64	A4
%	25	65	A5
z	26	66	A6
°	27	67	A7
d	28	68	A8
μ	29	69	A9
*	2A	6A	AA
+	2B	6B	AB
,	2C	6C	AC
−	2D	6D	AD
.	2E	6E	AE
/	2F	6F	AF
0	30	70	B0
1	31	71	B1
2	32	72	B2
3	33	73	B3
4	34	74	B4
5	35	75	B5
6	36	76	B6
7	37	77	B7
8	38	78	B8
9	39	79	B9
:	3A	7A	BA
s	3B	7B	BB
<	3C	7C	BC
=	3D	7D	BD
>	3E	7E	BE
?	3F	7F	BF

8-14. CONNECTION TO PLOTTER (TR9834R)

This section describes attachment of TR9834R Plotter to the TR4172 Analyzer.

First, connect the GP-IB connector on the rear of the TR4172 to that on the TR9834R with the supplied GP-IB cable. Then set the TR9834R to the LISTEN ONLY mode and power it up.

After setting up all measurement conditions on the TR4172, press [SHIFT] [LABEL] [Δ]. If the frequency axis is in the logarithmic scaling (see page 4-61), however, press only [Δ] key. The diplay will show the following message:

PLOT
'1' TR9831
'2' TR9834R
'0' QUIT

Press the Data key 2. The message displayed on the screen will change as shown below. If a TR9831 is connected to the TR4172, press the key 1. Pressing the key 0 returns the TR4172 to the status it was in before the [SHIFT] [LABEL] [Δ] switch was depressed.

PLOT
'1' LARGE
'2' SMALL
'0' QUIT

Press the Data key 1 (LARGE) to plot display data (waveforms, graticules, characters, markers, and labels) in A3 size, the key 2 (SMALL) to plot it in A4 size (size of this instruction manual). Pressing the key 0 will return the TR4172 to the status it was in before the [SHIFT] [LABEL] [Δ] switch was depressed. Where only character text, such as HELP messages, is displayed, plotting starts immediately. On a normal screen display, the following message appears after the LARGE/SMALL select switch is pressed.

PLOT

'1' ALL

'2' TRACE

'0' QUIT

Press the Data key 1 (ALL) to plot all display data, and the key 2 (TRACE) to plot waveforms only. The key 2 can be used to overlay a new waveform over previously plotted data.

Pressing the key 0 (QUIT) will return the TR4172 to the status it was in before the SHIFT LABEL switch was depressed.

After the ALL/TRASE select switch is pressed, the characters that had been displayed in the active area prior to the display of the above message are displayed again and plotting begins.

Pressing the key 0 during plotting cancels the plotting operation causing the initial PLOT message to be displayed.

After plotting, a single-page feed occurs unless only a waveform has been plotted. When a waveform is to be overlaid over previously plotted data, only the waveform should be plotted first.

The TR9834R Plotter can be operated in either one pen or two pen mode. Text information, graticule, and contents of memories A and A' are plotted by pen 1, while the contents of memories B and B' are plotted by pen 2. The contents of blanked memory will not be plotted, however. In the BOTH display mode, images A and B may be plotted in different colors if different color pens are used for pens 1 and 2.

When the TR9834R Plotter is attached to the TR4172 Analyzer, the TR4172 functions as a controller for the TR9834R. Therefore, no other devices or controller should, in principle, be attached to the TR4172.

When in the single display mode, signal response trace and graticule may be plotted in different colors if trace information is stored in memory B.

When using two pens, calibrate their relative positions by referring to the TR9834R <u>Instruction Manual</u>.

The recording paper for the TR9834R is available in roll and leaf papers. When leaf paper is to be used, the pen(s) may not automatically return to its (their) home position upon completion of plotting, with the REMOTE and PROMPT lamps flashing. If this occurs, press the position switches on the TR9834R to return the pen to its home position.

8-15. CONNECTION TO PLOTTER (TR9831)

Connection and operating procedures are the same as those of TR9834R. However, power the instrument on while the TR9831 FEED switch is being pressed.

The TR9831 allows the selective use of four pens, pens 1, 2, 3 and 4. Among the TR4172 display data, characters and graticules are plotted with pen 1 and the contents of traces A, B, A' and B' are plotted with pens 1, 2, 3 and 4 respectively. Blank traces are not plotted. (See Table 8-5.)

The following message is displayed when plotting with the TR9831 is disabled:

(ERROR) PLOTTER DOWN OR CONNECTOR DRAWN OUT

'1' COUTINUE

'0' QUIT

Table 8-5 Display data and pen correspondence

TR4172 display data	TR9831	TR9834R
Trace A	Pen 1	Pen 1
Trace B	Pen 2	Pen 2
Trace A'	Pen 3	Pen 1
Trace B'	Pen 4	Pen 2
Graticules	Pen 1	Pen 1
Characters	Pen 1	Pen 1

8-16. LEARN MODE

All the panel setup conditions on the TR4172 can be stored in the memory of the associated controller subsequently recalled.

In order to discriminate this feature from the ordinary save feature, the SH (SHIFT) and IN (SAVE) commands are suffixed with 0.

The following example shows a case where the panel setup conditions are stored in memory location A$ and are then recalled. As in Example 19 , be sure to set the dimension to 94 (twice (2E + 1) in hex) and store it in address 7400.

Example 19

```
1: dim A$  94
2: wrt 701, "SHINORD7400002E"
3: red 701, A$
        ⟆
   wrt 701, "LD7400", A$
   wrt 701, "SHLIO"
```

The panel setup conditions temporarily stored in memory location A$ are now recalled to the panel of the analyzer.

Example 20 shows a programming example using the Hewlett Packard Model HP-85A:

[Example 20]

```
1  DIM B$ [94]
2  DIM A$ [100]
3  A$ = "LD7400"
4  OUTPUT 701; "SHINORD7400002E"
5  ENTER 701; B$
7  A$ [7] = B$ ←— Insert B$ after "LD7400".
        ⟆
   OUTPUT 701; A$
   OUTPUT 701; "SHLIO"
```

8-17. Setting GPIB of Phase and Group Delay Relations

(1) When setting the phase range at phase measurement using GPIB, write PH (to place phases in the variable state), the corresponding number, and Hz, referring to Table 8-5.

Table 8-6 Setting phase range

Phase range	Set command
80°/div.	0 Hz
40°/div.	2 Hz
20°/div.	4 Hz
8°/div.	6 Hz
4°/div.	7 Hz
2°/div.	8 Hz
0.8°/div.	9 Hz
0.4°/div.	10 Hz
0.2°/div.	11 Hz

For example, when setting 20°/div., specify wrt701, "PH4HZ."

(2) Specify phase offset at addresses BEC0 and BEC1 and group delay offset at addresses BEC2 and BEC3 with hexadecimal characters (0 to 4095) in the low and high order. Specify group delay offset fine at address BEC5 with hexadecimal characters (0 to 255).

[Example 21]

Setting phase offset 1068 (42C in hexadecimal notation)

```
wrt701, "LDBEC02C04"
wrt701, "SHPH"
```

[Example 22]

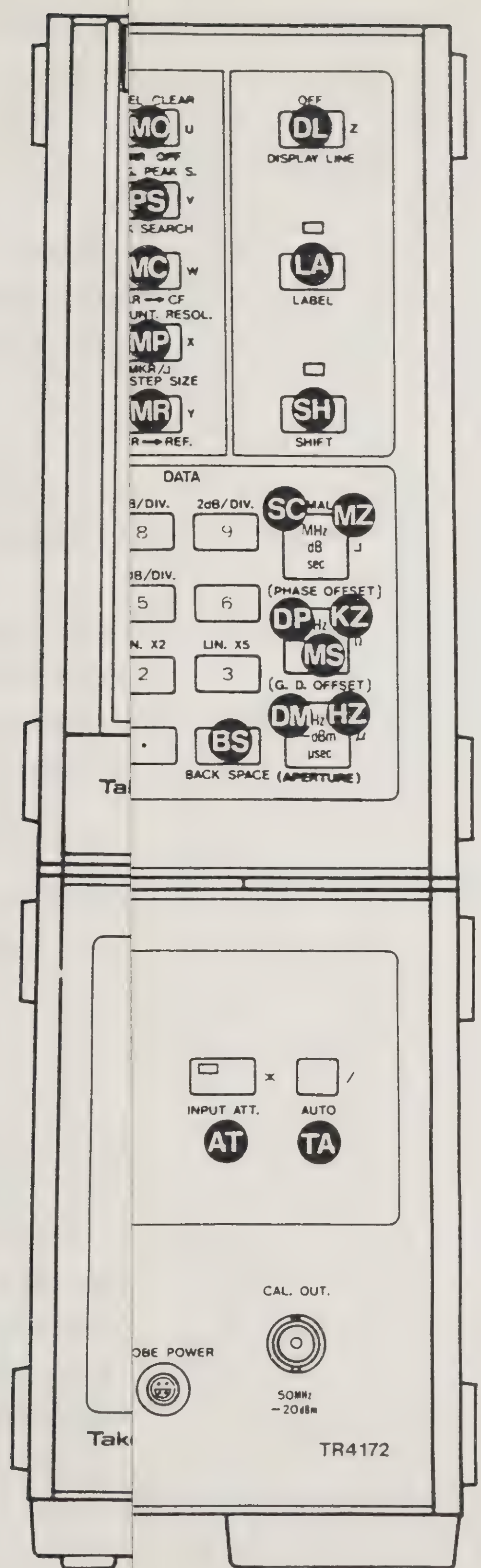
Setting group delay offset 1068 (42C in hexadecimal notation)

```
wrt701, "LDBEC22C04"
wrt701, "SHGD"
```

[Example 23]

Setting group delay offset fine 123 (7B in hexadecimal notation)

```
wrt701, "LDBEC57B"
wrt701, "GD"
```



CLEAR
MO
U
OFF
PEAK S.
PS
V
SEARCH
MC
W
CF
RESOL.
MP
X
STEP SIZE
MR
Y
REF.
OFF
DL
Z
DISPLAY LINE
LA
LABEL
SH
SHIFT
DATA
2dB/DIV.
SC
MZ
MHz
dB
sec
(PHASE OFFSET)
DP
KZ
MS
LIN. X5
(G. D. OFFSET)
DM
HZ
dBm
μsec
BS
BACK SPACE (APERTURE)
INPUT ATT.
AUTO
AT
TA
CAL. OUT.
50MHz
−20dBm
TR4172

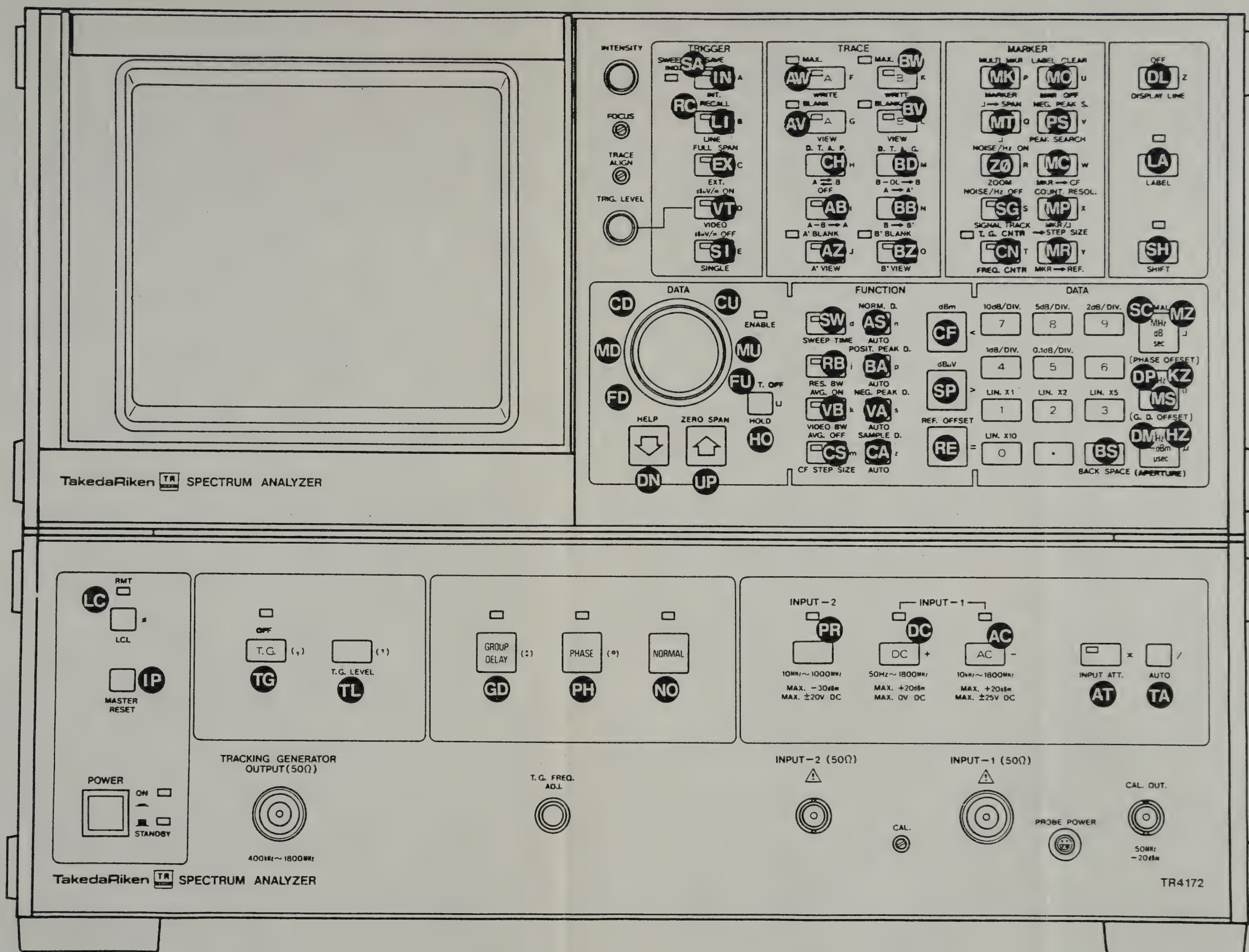


Fig. 8-6 GPIB command

SECTION 9

IMPEDANCE MEASUREMENT (OPTION 05)

9-1. GENERAL

This option, when combined with the VSWR bridge, provides a Smith chart display on the TR4172's CRT display to allow for impedance measurement. It also permits direct readout of VSWR, reflection coeficient, and normalized impedance values useful for reflection wave analysis. In addition, the option makes various arithmetic and logical operating features using the internal CPU available for impedance measurement, offering the high-stability, high-sensitivity measurement for which the TR4172 is designed.

This section describes the theory of impedance measurement, the calibration procedure required for impedance measurement, and explains the impedance measurement procedure in some detail.

The impedance measurement mode is selected by pressing $\boxed{\text{SHIFT}}$ $\boxed{\text{LABEL}}$ $\boxed{0}$. Once this mode is selected, functions of the control keys on the front panel are different from the usual ones. The key functions available in this mode are listed in Figure 9-36.

9-2. THEORY OF OPERATION

When a VSWR bridge is connected across the TRACKING GENERATOR OUTPUT and INPUT-1 of the TR4172 Analyzer and a Device Under Test (DUT) is connected to the Analyzer via this VSWR bridge, a signal proportional to the reflection from the DUT is input to INPUT-1. If the DUT terminals on the bridge are shorted or open (full reflection), the input to the INPUT-1 is maximized; if a characteristic impedance of the bridge is connected to the DUT terminals, then the input to INPUT-1 is minimized.

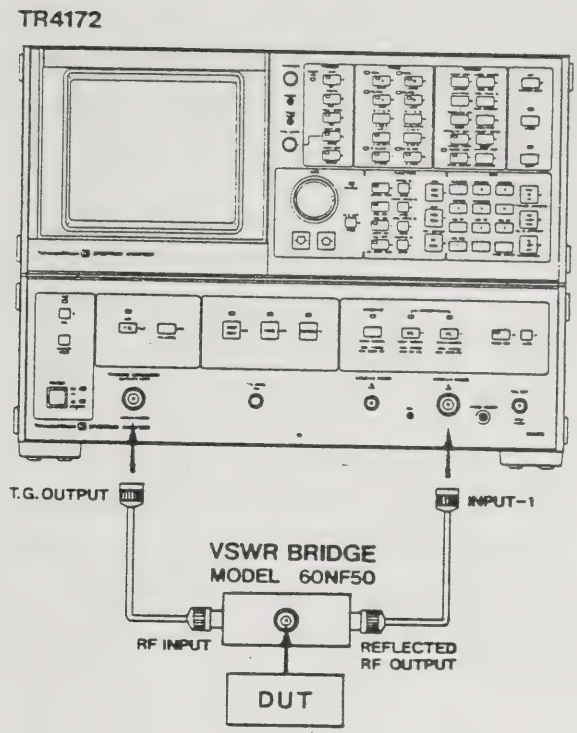


Fig. 9-1 Impedance measurement setup

The return loss of the DUT (difference between the reflection from the DUT and full reflection) can be determined by reading the input level on a logarithmic scale. If the input amplitude is displayed on a linear scale and the reference level is set to the full reflection level, the reflection coefficient can be directly read out at a resolution of 0.1 div. Furthermore, the reflection coefficient can be handled as a vector by phase measurement.
Figure 9-2 shows how the option reads phase information upon the first sweep, then reads amplitude information of linear scale upon the second sweep.

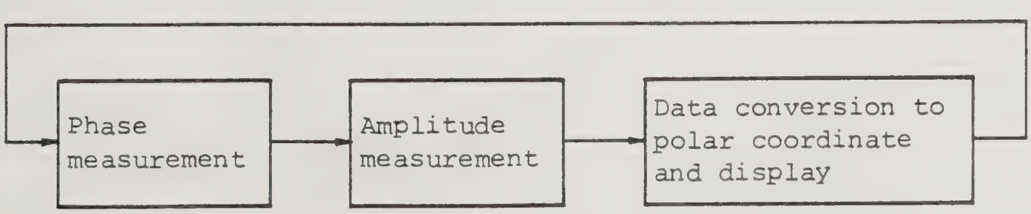
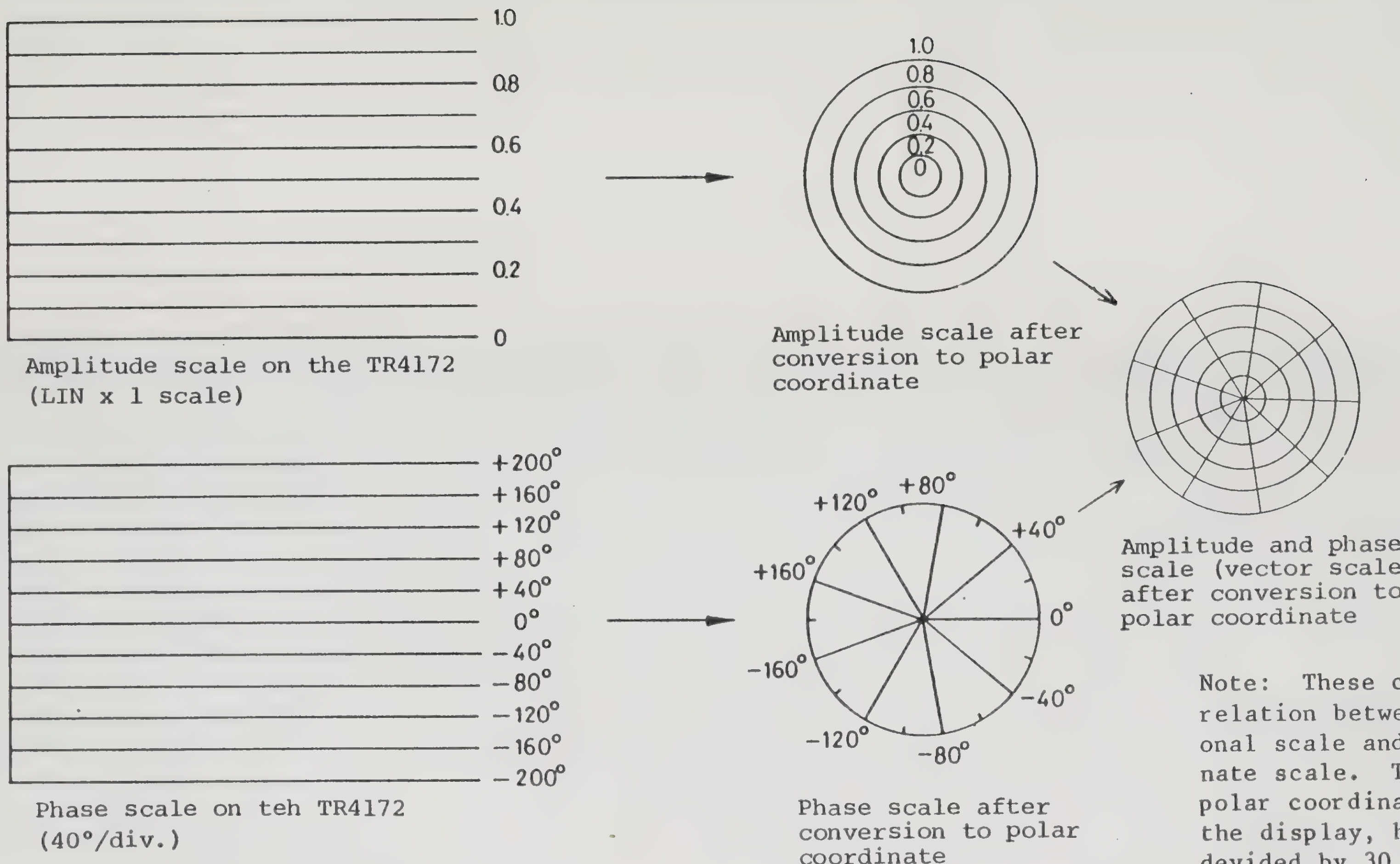


Fig. 9-2 Impedance measurement and display information flow

The information is then translated into polar coordinate data by arithmetic operation and displayed on the monitor (see Figure 9-3). Figure 9-4 shows amplitude, phase, and polar-coordinate displays for the same device under test.

A normalized impedance value can be read by superimposing a Smith chart on the reflection coefficient data displayed on a polar coordinate. Since the option can show a Smith chart on the display, approximated normalized impedance can be read from the display.

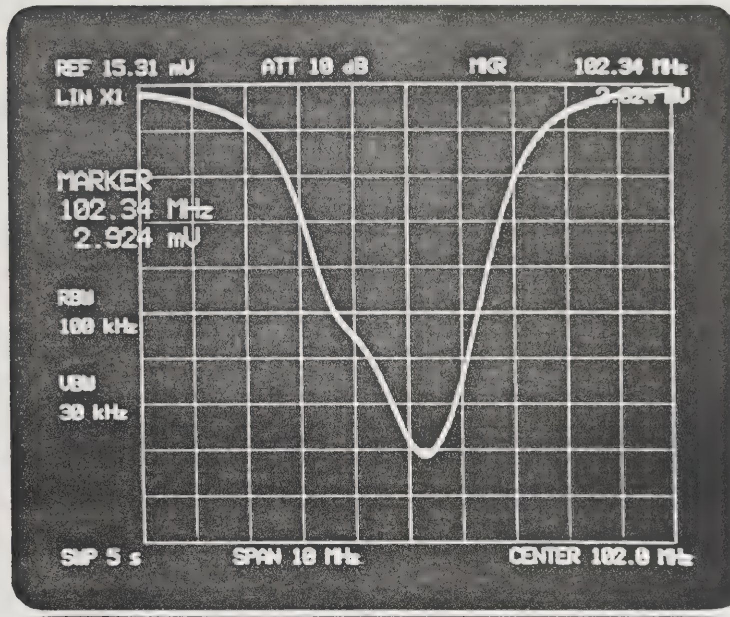
When a marker is used, the marker frequency, VSWR, reflection factor, phase, and normalization impedance are digitally displayed. For this option, transfer characteristics can be displayed with vectors using only the polar-coordinate display function. In this case, directly connect DUT between TRACKING GENERATOR OUTPUT and INPUT-1.



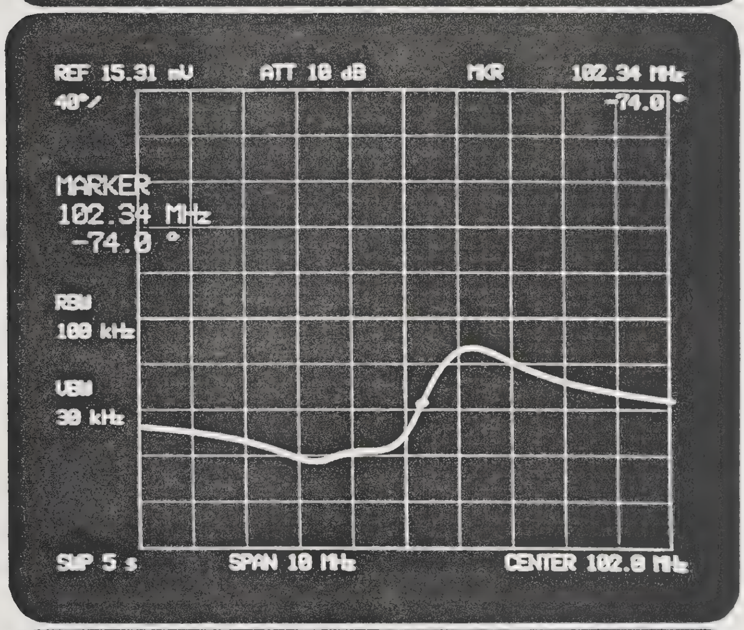
Note: These charts show the relation between the orthogonal scale and polar coordinate scale. The actual polar coordinate scale on the display, however, is devided by 30 degree as shown in Figure 9-4.

Fig. 9-3 Amplitude and phase information translated into polar coordinate data

Amplitude display



Phase display



Polar coordinate display

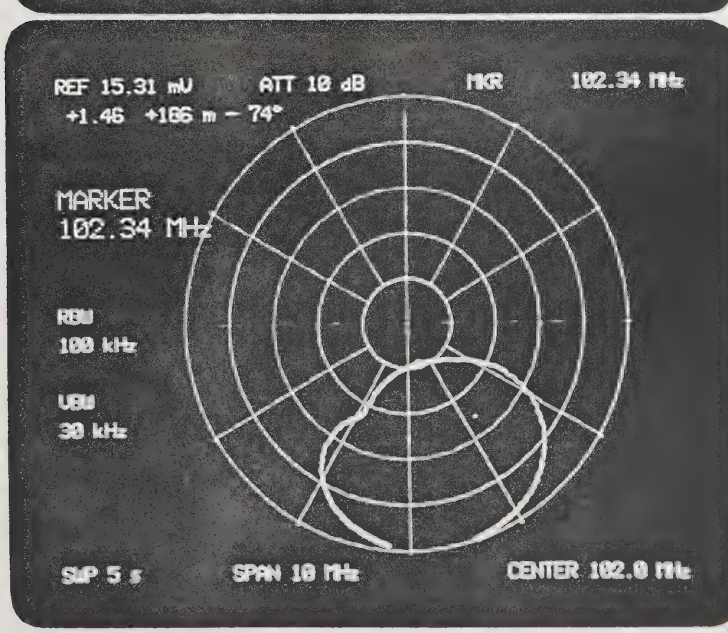


Fig. 9-4 Amplitude, phase, and polar-coordinate displays for the same DUT

9-3. CALIBRATION

9-3-1. General

When measuring impedance or reflection-coefficient using a VSWR bridge, calibration must be done to cancel the loss of the VSWR bridge, electrical length of the cable, and other error factors. For this calibration, a short or open plug is connected to the DUT terminals on the VSWR bridge instead of a real DUT, and the reference level, group delay offset, and phase offset are adjusted so the display data comes to the 0 Ω or ∞ Ω point on the Smith chart. When a frequency span of several 10 MHz or more is selected, however, satisfactory calibration may not be possible due to the nonlinear frequency response of the tracking generator or VSWR bridge. In order to solve this problem, the option contains a frequency response correction feature for both amplitude and phase. Since calibration directly affects measurement accuracy, the open or short plugs used should have nearly ideal characteristics in the given frequency range.

9-3-2. Preparation for Calibration

Connect the VSWR bridge across the TRACKING GENERATOR OUTPUT and INPUT -1 of the TR4172 by means of interconnecting cables DGM010-00150A (see Figure 9-5).

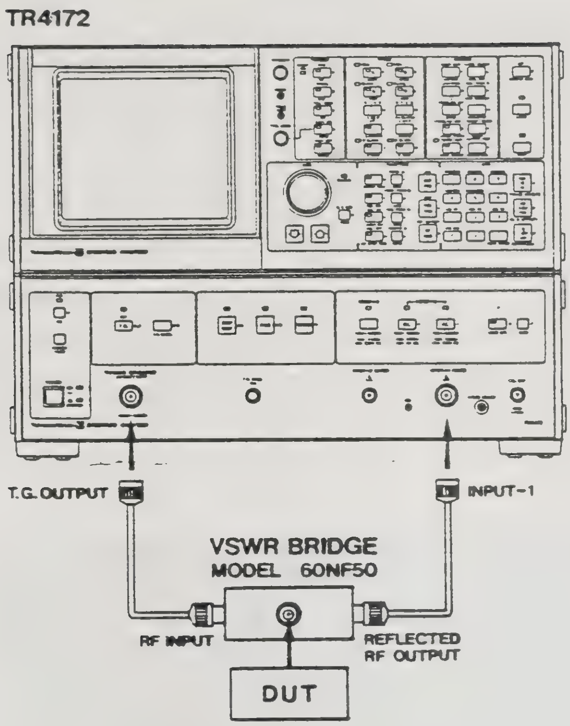


Fig. 9-5 Calibration system setup

The recommended VSWR bridge is 60NF50.
Connect the DUT across the terminals on the VSWR bridge, then press the TG key to activate the tracking generator output. While viewing the pass-band response of the DUT, set up the center frequency, frequency span, and other necessary parameters. Use the TG LEVEL key to adjust the signal level applied to the DUT. The signal level actually applied to the DUT is 6 dB to 7 dB lower than the tracking generator output level (when the recommended VSWR bridge is used). Since impedance measurement involves phase measurement, press the SWEEP TIME key, then manually select the appropriate sweep time with the DATA knob or other control means.

9-3-3. Calibration Procedure

Disconnect the DUT from the terminals on the VSWR bridge, and connect an short or open device to the terminals. If the DUT is connected by a cable, leave the cable connected to the terminals, and connect the short or open device to the end of that cable. In some frequency area, an open connector has its own capacity. In this case, use a short connector.

Press the PHASE key to observe phase response, then adjust group delay offset with the kHz (G.D. OFFSET) key until phase rotation is cancelled out.

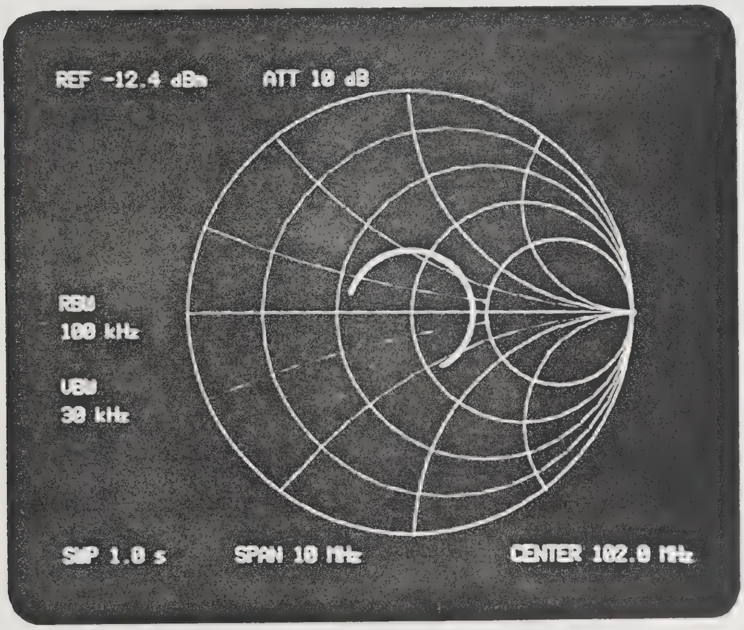


Fig. 9-6 Impedance measurement start

Press [SHIFT] [LABEL] [0] to activate the impedance measurement option. Figure 9-6 shows a Smith chart on the display, and impedance measurement sweep is started to display the measurement information translated into polar coordinate data. The display information is updated every other sweep.

The center frequency, frequency span, and other parameters set up during preparation are also maintained during impedance measurement. Press the REF LEVEL key, then use the DATA knob to align the measurement information to the outermost circumference of the Smith chart.

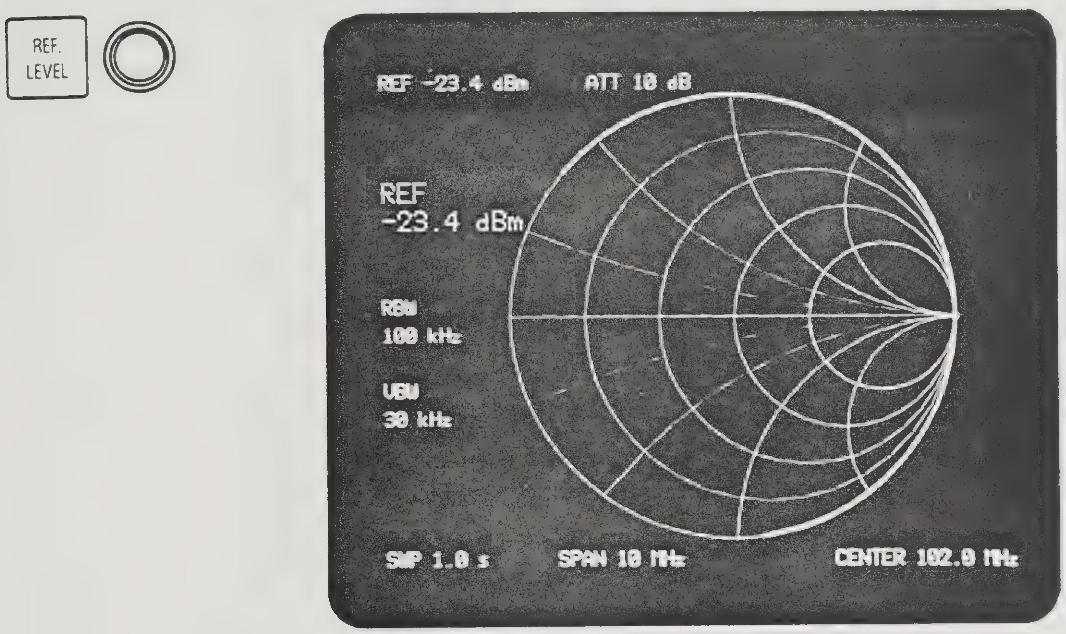


Fig. 9-7 Positioning the display information to the outermost circumference of the Smith chart

Press 

, then use the DATA knob to converge the display data to as small a point as possible. For finer adjustment, press the kHz key before controlling the DATA knob. To prevent the bright data spot from burning the display screen, press the PEAK SEARCH (POINT DEC.) key several times to reduce the number of data points. As mentioned earlier, the impedance measurement mode causes the control keys on the front panel to have functions different from their normal functions. For those functions refer to Figure 9-36.

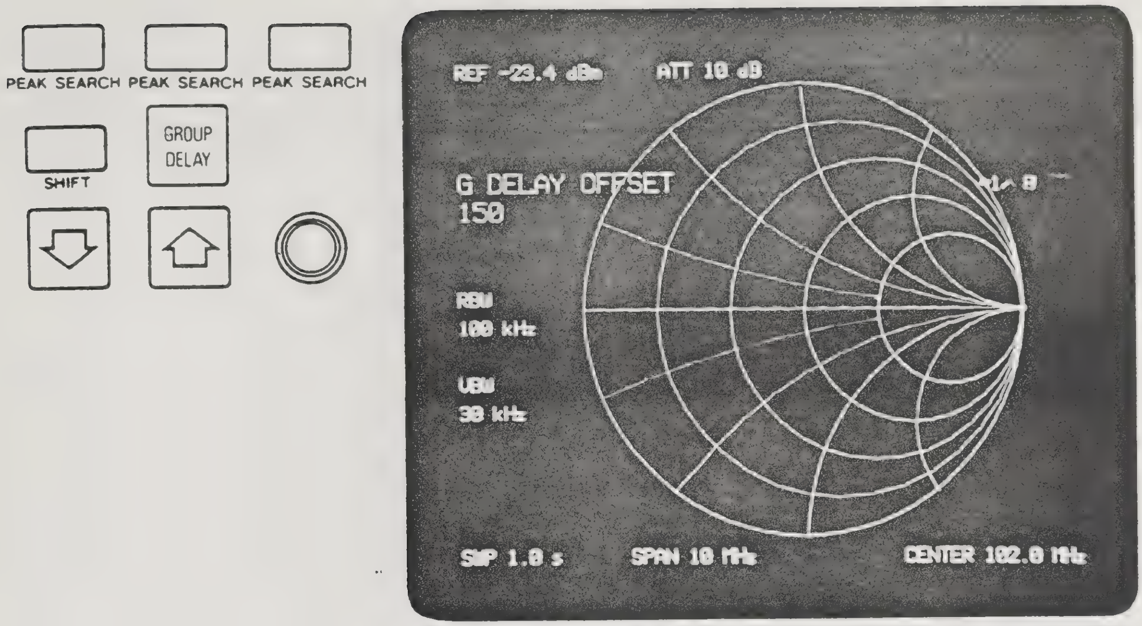


Fig. 9-8 Converging the display data to a small spot

Press SHIFT PHASE , then use the DATA knob and step keys to cancel phase offset. If an open device is connected to the DUT terminals on the VSWR bridge, position the data spot to the ∞ Ω point (right-hand end) on the Smith chart. If a short device is connected to the terminals, position the data spot to the 0 Ω point (left side) of the Smith chart.

Fig. 9-9 Calibration for DUT terminal open

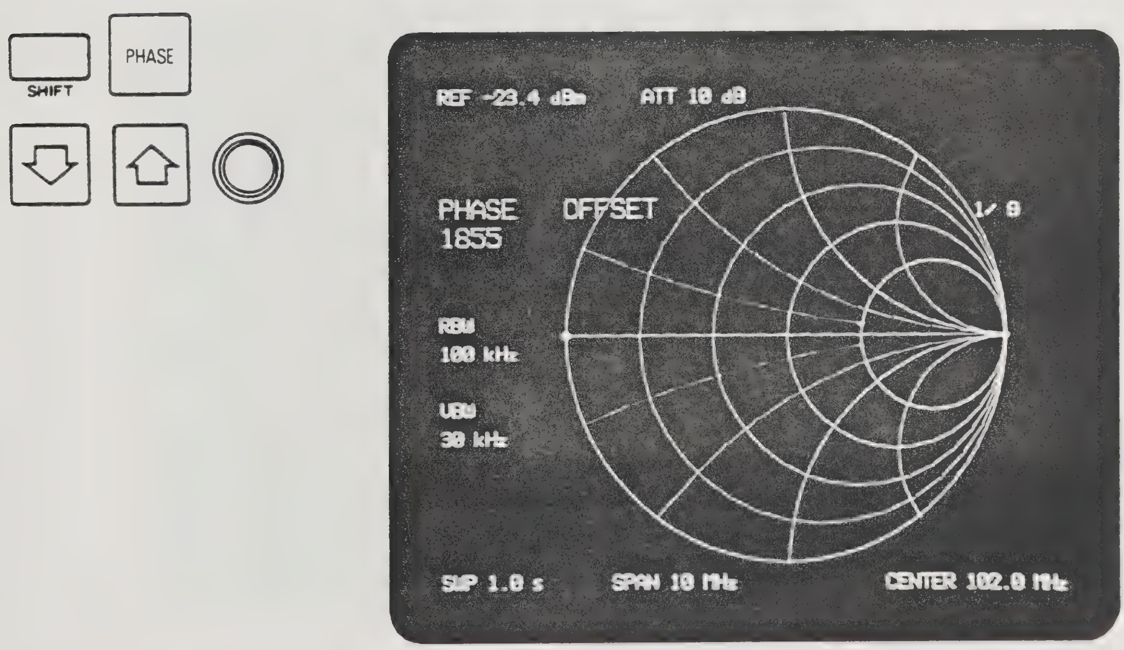


Fig. 9-10 Calibration for DUT terminal shorted

Calibration has now been completed. The same calibration procedure may be used for the amplitude and phase measurement mode while viewing the orthogonal coordinate (and by using the relationship shown in Figure 9-3). In this case, calibration time will be shortened since display updating interval for the orthogonal coordinate is shorter than that for the Smith chart.

9-3-4. Frequency Response Compensation

Calibration has been completed through the described procedure. If the data spot is not converged to the ∞ Ω or 0 Ω point on the Smith chart as shown below, proceed with the following operations. If the data spot is properly converged to the 0 Ω or ∞ Ω point, then proceed to paragraph 9-3-5.

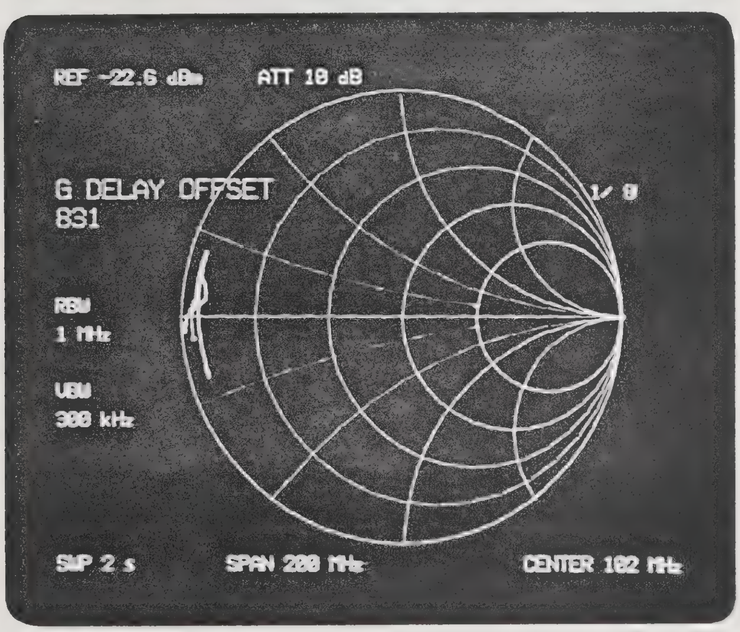


Fig. 9-11 Unconverged data spot

The unconverged data spot is due to lack of frequency-response flatness in the phase or amplitude domain. Correct the frequency response as follows:

For frequency response compensation in the phase domain, press the N (PHASE COR.) key to select the phase correction mode. The display will show "PH-COR" in its information display area. To calibrate the phase response, press 0 (PHASE CAL.(0)) key when an open device is connected to the DUT terminals on the VSWR bridge, or the S (PHASE CAL.(S)) key when a short device is connected to the same terminals. The frequency response in the phase domain is now corrected.

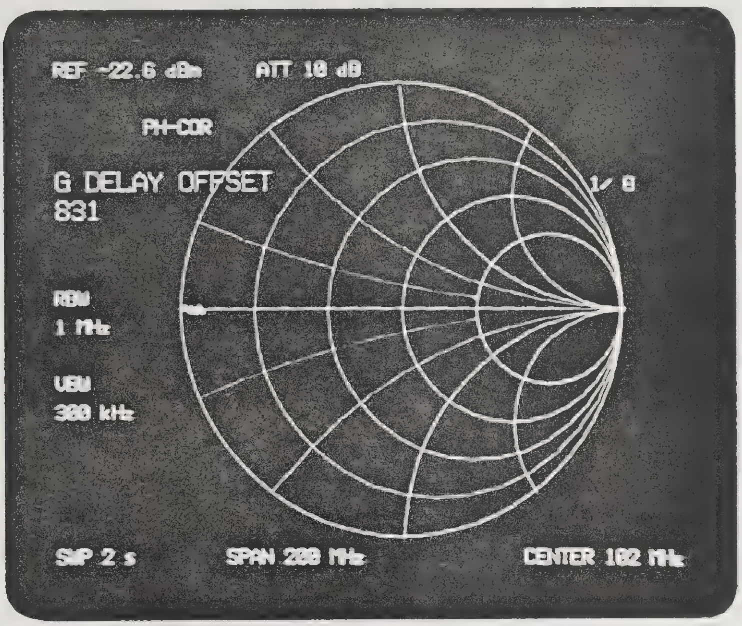


Fig. 9-12 Frequency response correction in the phase domain

For frequency response correction in the amplitude domain, press the I (MAG. COR.) key to select the amplitude correction mode. The display will show "MG-COR" in the information display area. Then press the J (MAG. CAL.) key to calibrate amplitude response. Figure 9-14 shows the correctable amplitude range. Corrections performed outside this range results in error, and the "ERROR" message will be shown just below "MG-COR" on the display. If this occurs, press the I (MAG. COR.) key again to clear the amplitude correction mode, then press the REF LEVEL key and use the DATA knob until the display data comes inside the correctable range. Press the I (MAG. COR.) key again to calibrate the amplitude response.

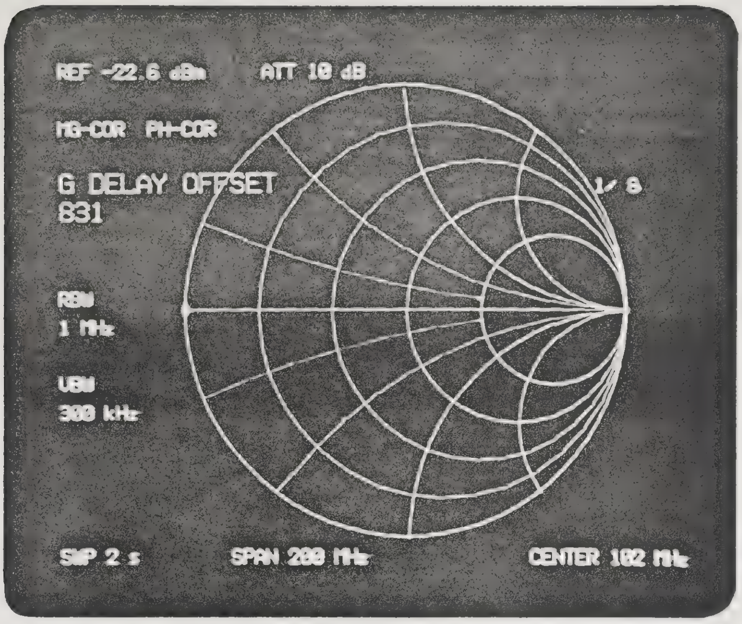


Fig. 9-13 Frequency response correction in the amplitude domain

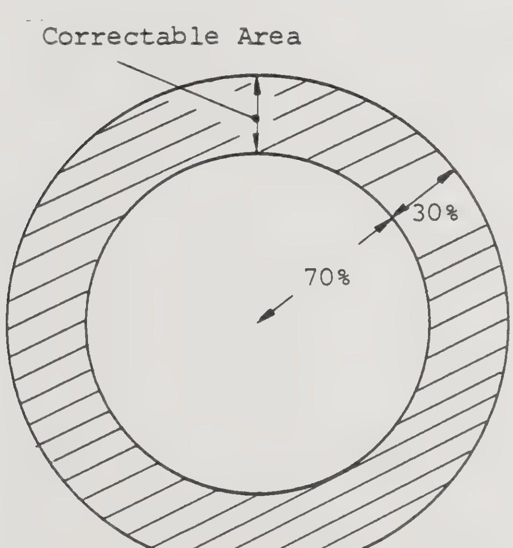


Fig. 9-14 Amplitude-frequency response correctable range

9-3-5. Calibration in Enlargement Mode

The center portion of a Smith chart display can be enlarged 10 times by pressing the R (MAG. x 10) key. The enlargement will result in a slight phase error. To cancel this phase error, connect an open or short device to the DUT terminals on the VSWR bridge, and adjust phase offset so that the phase is 0° for an open terminal or 180° for a shorted terminal. When the display data overscale, that is unimportant.
If the R (MAG. x 10) key is pressed again, the Smith chart display of normal size will be restored. In this case also, carry out phase calibration. If the slight phase error occurring in the enlargement mode is insignificant, the phase calibration may be omitted.

9-4. MEASUREMENT

9-4-1. Measuring Procedure

Accurate calibration is a vital factor for precision impedance measurement. Once calibration is completed, do not change the center frequency, frequency span, reference level, or other parameter setting. If any change is effected on these parameters, carry out calibration again.
After completing calibration, connect the DUT across the DUT terminals on the VSWR bridge. The impedance of the DUT can now be read on the Smith chart display. Figure 9-15, 9-16, and 9-17 show the three types of scales used for this option. Figure 9-15 shows a Smith chart from which a normalized impedance can be read. The normalized impedance at the point indicated by a small mark "o" in this figure is read as 0.2 Ω- j0.5 Ω. Figure 9-16 shows a polar coordinate from which a reflection coefficient can be determined. The reflection coefficient at the point identified by small mark "o" in this figure is read as $0.8 \angle 60$ deg. Figure 9-17 shows another Smith chart whose center portion is enlarged tenfold. A normalized impedance in the vicinity of 1 can be determined from this chart at a high resolution.

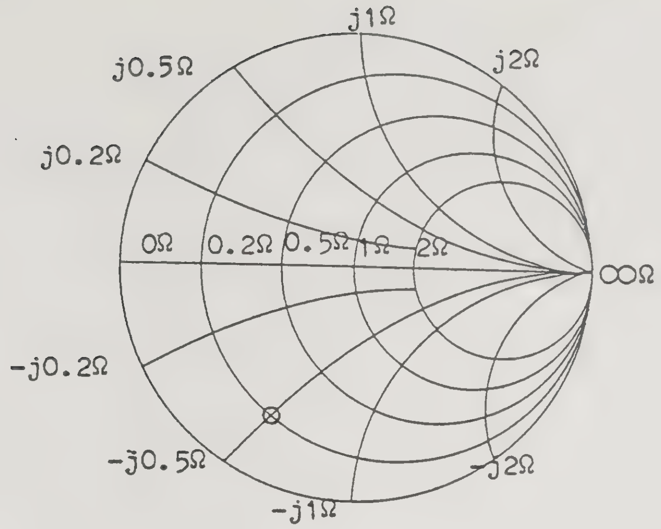


Fig. 9-15 Smith chart

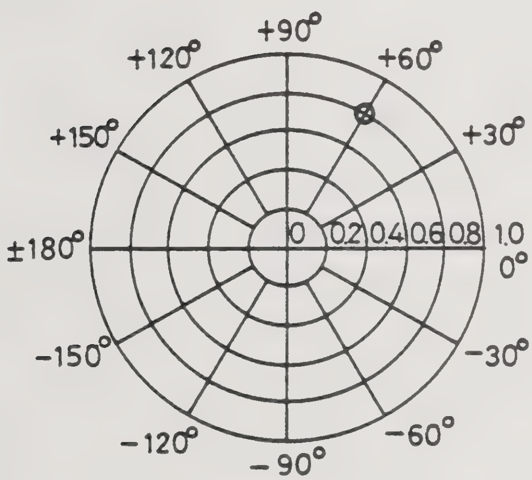


Fig. 9-16 Polar coordinate

The impedance can be determined by multiplying the real and imaginary parts of the normalized impedance each by 50 (when the characteristic impedance of the bridge is 50 Ω).

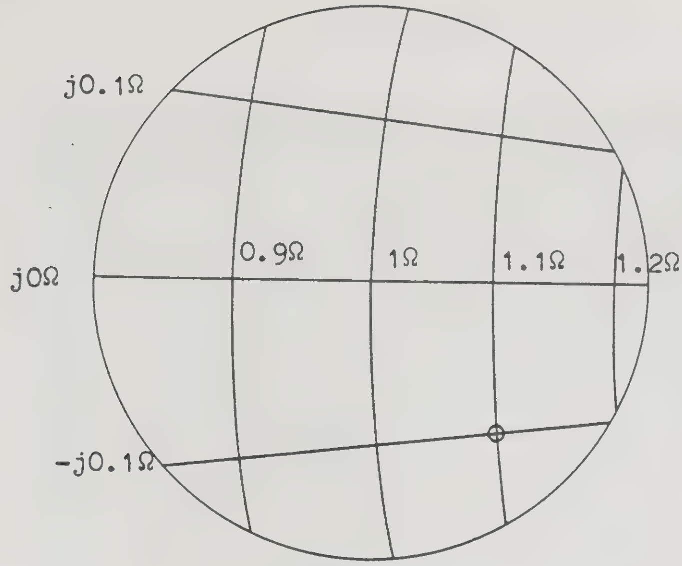


Fig. 9-17 Enlarged Smith chart

The frequency of the display data can be read with a marker activated by operating the MARKER key. In addition to the frequency, the display will also provide direct readouts for the VSWR, reflection coefficient, phase, normalized impedance, and inductance or capacitance of the equivalent serial circuit. The normalized impedance and inductance or capacitance of the equivalent serial circuit are not shown on the polar coordinate display, however. Figure 9-18 shows a data display example using a marker. Calculated data readouts for the marker point are shown on the third line on the screen. The readouts are VSWR, reflection coefficient, phase, normalized impedance, and inductance or capacitance, from left to right. The top information line on the display is reserved for user-defined Label information. If no label is written in this area, however, the titles for the data readouts shown on the third line are shown on this top line instead. If even one character of label information is entered in this line, the title will not be shown. While normalized impedance, inductance, and capacitance each have three significant digits, it shoud be noted that they may include a large error if the real or imaginary part of the impedance to be measured is extremely large or extremely small with respect to the characteristic impedance.

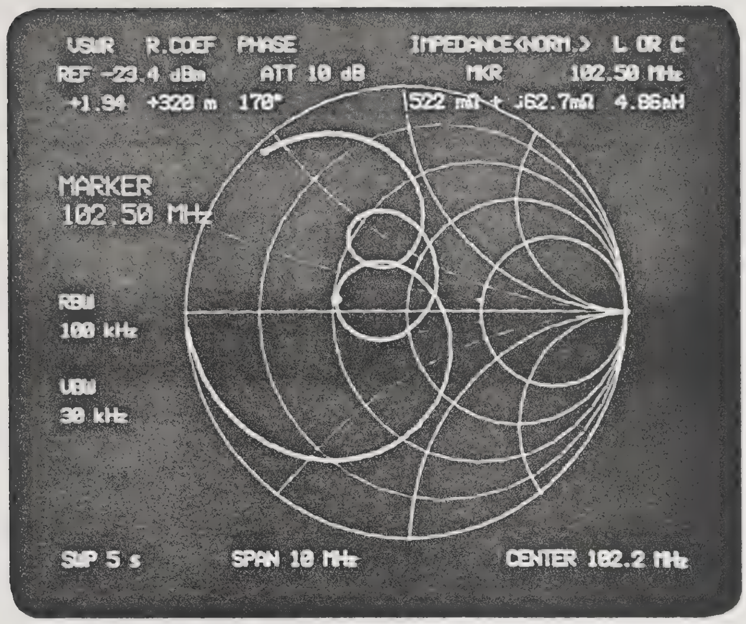


Fig. 9-18 Data readout for marker point

The data redouts for the marker point are updated every other sweep. If the measurement information is held with the VIEW A key, however the data readouts will be updated with marker movement.

The measurement information hold state can be cleared by pressing the WRITE A key.

As with the normal measurement mode, the center frequency, frequency span, reference level, and marker can be set up with any of the DATA knob, DATA step keys, and numeric data keyboard.

To clear the impedance measurement option mode, press the WRITE B (EXIT) key. At this time, the center frequency, frequency span, and other parameter setup are left intact, so that data comparison can be easily made between the normal mode and impedance measurement mode (e.g. a return loss is measured on the logarithmic scale, and the impedance is measured in the impedance measurement mode).

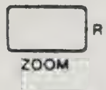
The basic impedance measuring procedure is described above. The following paragraphs describe various additional features available in the impedance measurement mode to facilitate measurement.

9-4-2. Usage of Additional Features

In the impedance measurement mode, there are some inoperative or unnecessary keys on the front panel. These keys are either made ineffective or assigned functions unique to this mode. (See figure 9-36.) Some keys with new function assignments are alternately activated and deactivated each time they are pressed. Some other keys are used to increment or decrement setup values (e.g. intensity) each time they are pressed. The lamps in these keys are not activated, but the setup conditions are shown on the display. VSWR or reflection coefficient values are displayed with engineering units such as "m" or "k". For instance, 12.3 m means 0.0123. The following paragraphs describe each additional function:

(1) Scale controlling function
Keys A and B select the Smith chart and polar coordinate scales respectively. If the R (MAG. x 10) key is pressed when the Smith chart is selected, the reference level is reduced to one-tenth, and the center portion of the chart is enlarged tenhold. (See figure 9-19.) At this time, phase offset must be canceled if necessary. (See paragraph 9-3-5.) Pressing the R key again will restore the normal Smith chart and the original reference level.

(2) VIEW mode and impedance measurement mode clear
Operation of VIEW A key stops sweep and holds measurement information on the display, so that photographing is facilitated. At this time, message "VIEW" will be shown in the right information area on the display. To clear the information hold state, press WRITE A key. Pressing WRITE B key clears the impedance measurement mode and returns the instrument to the normal measurement mode.



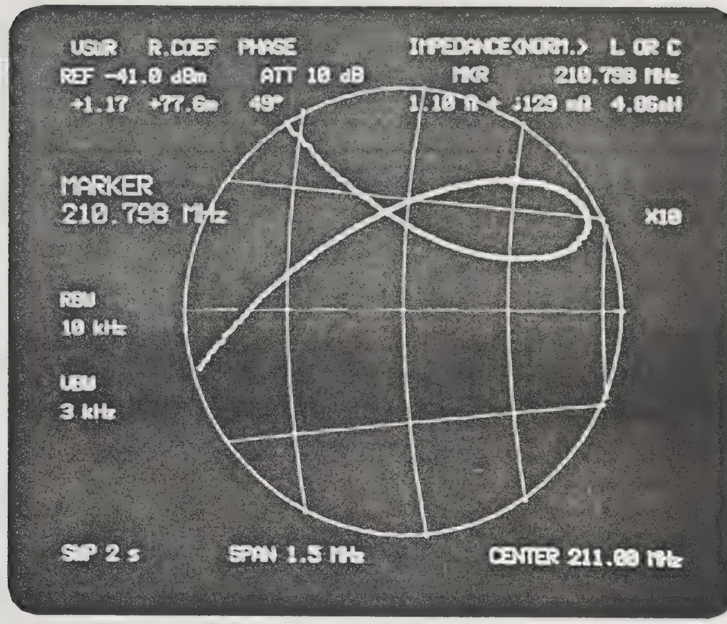


Fig. 9-19 Enlarged Smith Chart

(3) Increment and decrement of data points

Measurement data on the display usually consists of 500 data points. The number of data points can be reduced in half however, to 1/32 each time the V (POINTS DEC.) key is pressed. The reduction ratio is shown on the display as, for example, 1/16. To increase the number of data points, press the W (POINTS INC.) key. The number of data points is doubled each time this key is pressed. (See Figure 9-20.)

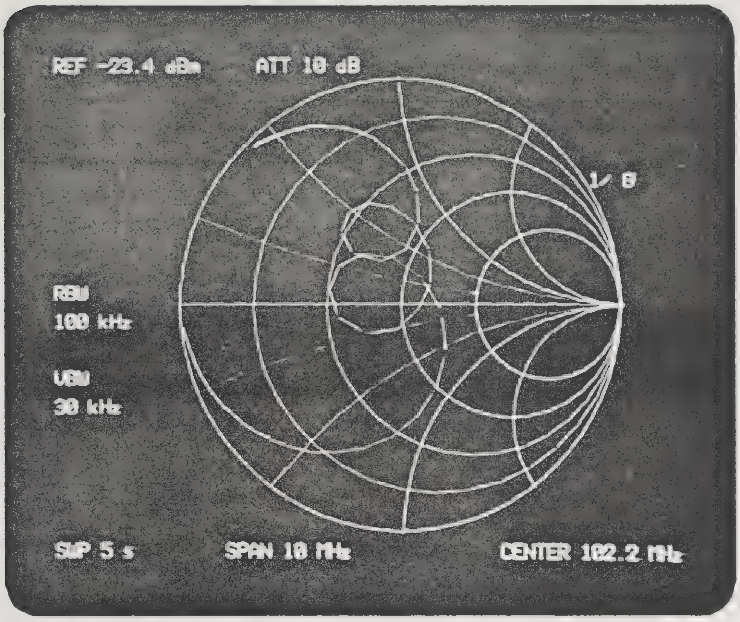


Fig. 9-20 Increment and decrement of data points

When measurement data is converged to one small spot on the display, reduce the number of data points to prevent the CRT from spot burn. If the number of data points is reduced, the time required for polar coordinate translation can be reduced accordingly.

(4) Direct numeric data readout

Direct numeric data readout can be obtained from display traced by the display circle and start-stop marker features, as well as the normal marker. Operation of the Z (DISP. CIRCLE) key shows a concentric circle of the polar coordinate on the display, along with message "DISPLAY CIRCLE". The radius of this circle can be varied by the DATA knob or DATA step keys.

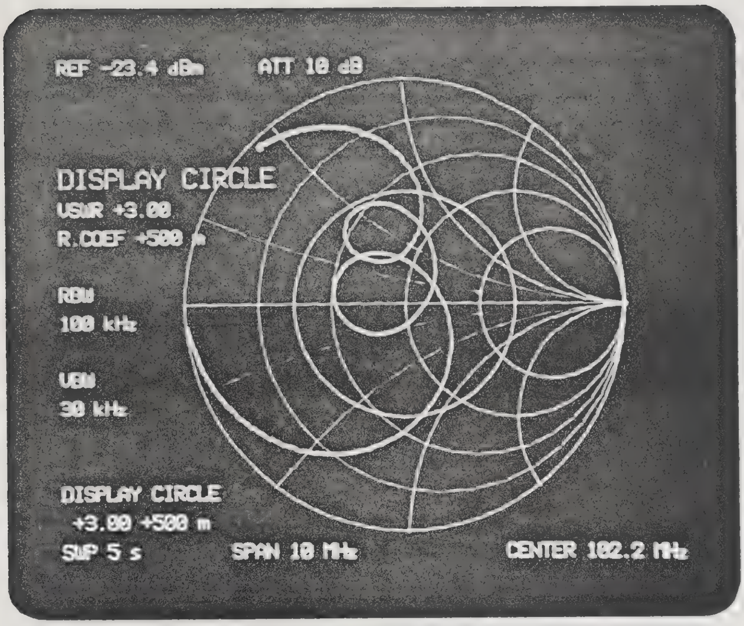


Fig. 9-21 Display circle

The VSWR and reflection coefficient values corresponding to the circle are read out on the display. They are shown on the left and right sides in the bottom left information display area. To superimpose the display circle on the marker point, press the Y (MKR→DC) key. Pressing the Z (DISP. CIRCLE) key again clears the display circle from the display. Pressing the L (START STOP) key shows the START STOP message, under which the sweep start and stop frequencies are displayed. The start and stop frequencies correspond respectively to the leftmost and rightmost graticules on the orthogonal coordinate. At the same time, triangular markers indicate the start and stop points on the display. (See Figure 9-22.) The acute-angle triangle indicates the start point, while the obtuse-angle triangle indicates the stop point. Pressing the L (START STOP) key again clears the start/stop frequency readouts.

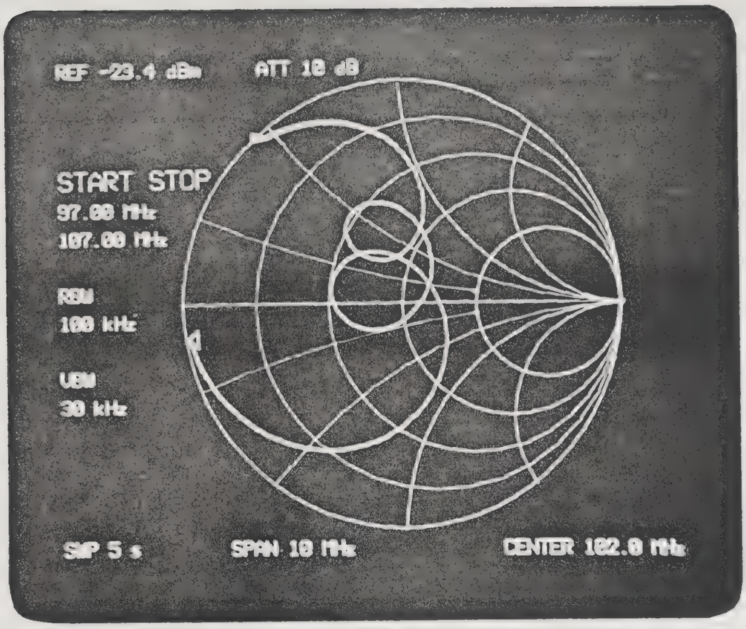


Fig. 9-22 Start and Stop markers

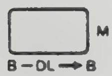
(5) Multimarker listing function

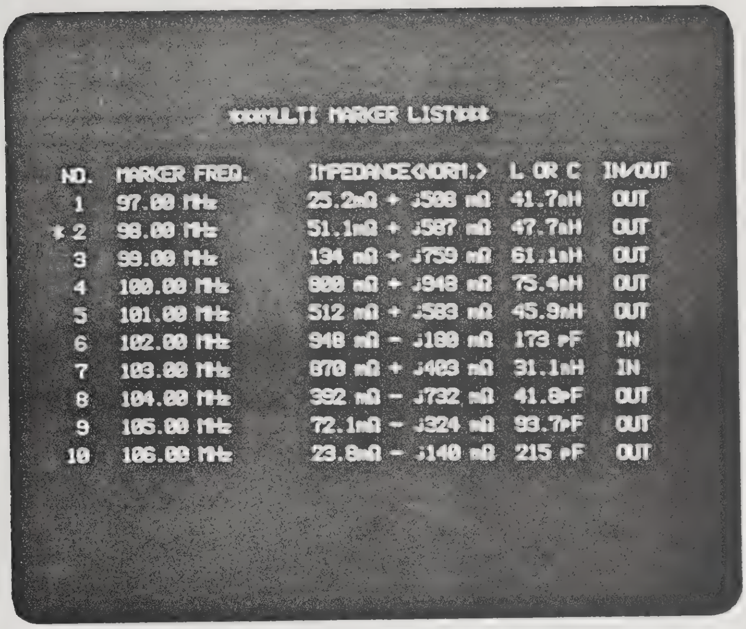
Multimarker setting is effected by following the same procedure as in normal mode. When a number of markers are displayed with the multimarker, pressing the [ ]M switch allows the values of the frequency, normalized impedance, and serial equivalent inductance or capacitance at up to 10 marker points to be listed on the display. The active marker is identified by an asterisk (*) to the left of its point number. If a display circle has been displayed, "IN" or "OUT" indicates whether a marker point has entered the circle or not.

Pressing the [ ]M switch here displays a list of VSWR values, reflection coefficients, and phases.

Pressing the [ ]M switch next will cancel this mode.

Be sure to press the [A] (VIEW) switch to hold measurement data before entering this mode.

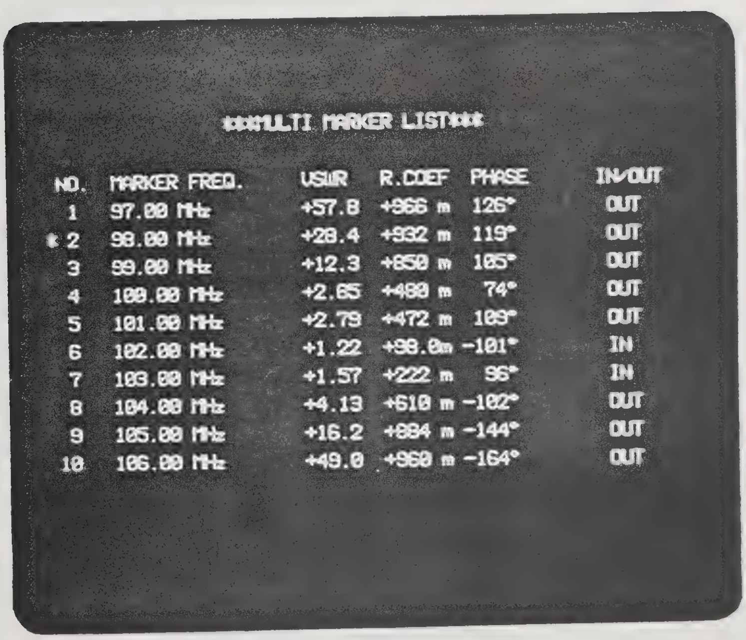




MULTI MARKER LIST

NO.	MARKER FREQ.	IMPEDANCE(NORM.)	L OR C	IN/OUT
1	97.00 MHz	25.2mΩ + j508 mΩ	41.7nH	OUT
* 2	98.00 MHz	51.1mΩ + j587 mΩ	47.7nH	OUT
3	99.00 MHz	134 mΩ + j759 mΩ	61.1nH	OUT
4	100.00 MHz	800 mΩ + j948 mΩ	75.4nH	OUT
5	101.00 MHz	512 mΩ + j583 mΩ	45.9nH	OUT
6	102.00 MHz	948 mΩ − j180 mΩ	173 pF	IN
7	103.00 MHz	870 mΩ + j403 mΩ	31.1nH	IN
8	104.00 MHz	392 mΩ − j732 mΩ	41.8pF	OUT
9	105.00 MHz	72.1mΩ − j324 mΩ	93.7pF	OUT
10	106.00 MHz	23.8mΩ − j140 mΩ	215 pF	OUT

Fig. 9-23 Normalized impedance and L/C listing



MULTI MARKER LIST

NO.	MARKER FREQ.	VSWR	R.COEF	PHASE	IN/OUT
1	97.00 MHz	+57.8	+966 m	126°	OUT
* 2	98.00 MHz	+28.4	+932 m	119°	OUT
3	99.00 MHz	+12.3	+850 m	105°	OUT
4	100.00 MHz	+2.65	+480 m	74°	OUT
5	101.00 MHz	+2.79	+472 m	109°	OUT
6	102.00 MHz	+1.22	+98.0m	−101°	IN
7	103.00 MHz	+1.57	+222 m	96°	IN
8	104.00 MHz	+4.13	+610 m	−102°	OUT
9	105.00 MHz	+16.2	+884 m	−144°	OUT
10	106.00 MHz	+49.0	+960 m	−164°	OUT

Fig. 9-24 VSWR, reflection coefficient, and phase listing

(6) Frequency response correction feature (See 9-3-4.)

This feature is used for pre-measurement calibration. Operation of the I (MAG. COR.) key selecters the amplitude frequency response correction mode. Pressing the J (MAG. CAL.) key effects calibration. If there is any data outside the correctable range, an error will result, with an ERROR message shown on the display. During calibration busy, the indicator "CAL" is also shown on the display. This correction mode is cleared by pressing the I (MAG. COR.) key again. (See Figure 9-23.)

Operation of the N (PHASE COR.) key selects the phase frequency response correction mode. To execute calibration, press the O (PHASE CAL. (O)) key when the DUT terminals on the VSWR are open, and press the S (PHASE CAL (S)) key when the terminals are shorted. During calibration busy, indicator CAL (O) or CAL (S) is shown on the display. This correction mode is cleared by pressing the N (PHASE COR.) key again.

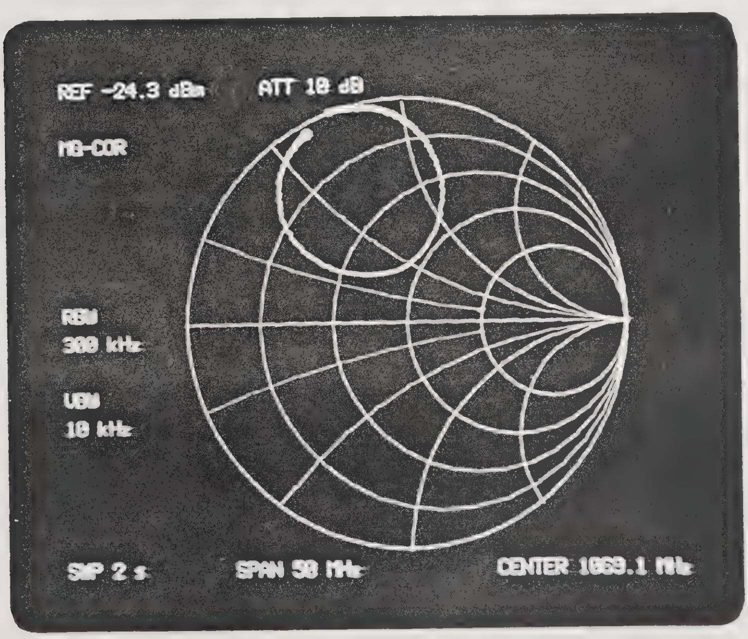


Fig. 9-25 Amplitude response correction mode

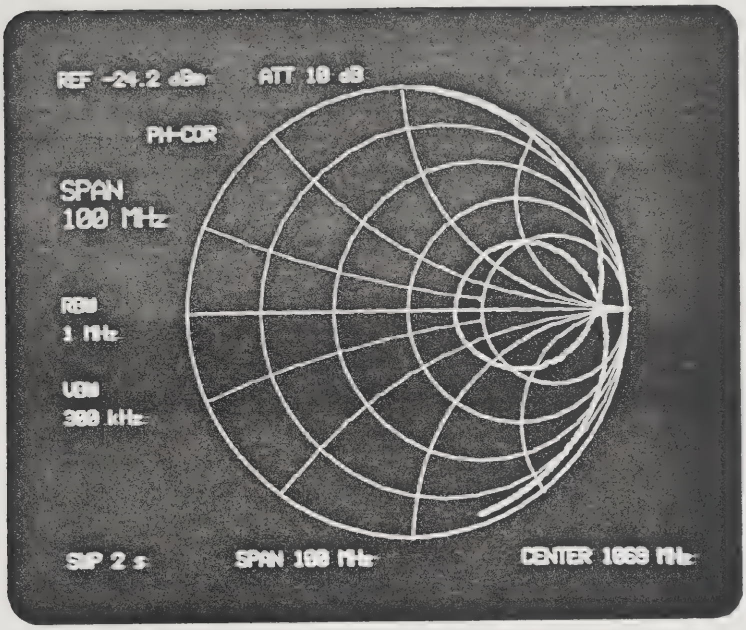


Fig. 9-26 Phase response correction mode

(7) Other features

Each operation of the T (CONTRAST) key increments only the intensity of the displayed impedance response trace or the graticule. The character information readouts remain at the same intensity. Operation of this key first increases the trace intensity in four levels; if the T (BRIGHT) key is pressed a fifth time, the intensity returns to the original level. Next, operation of this key increases the graticule brightness. This trace and graticule intensifying feature is convenient for highlighting the impedance response trace for photographing, or other occasions.

Operation of the H (HELP) key provides a listing of the special key functions used in the impedance measurement mode on the display (See Figure 9-27.)

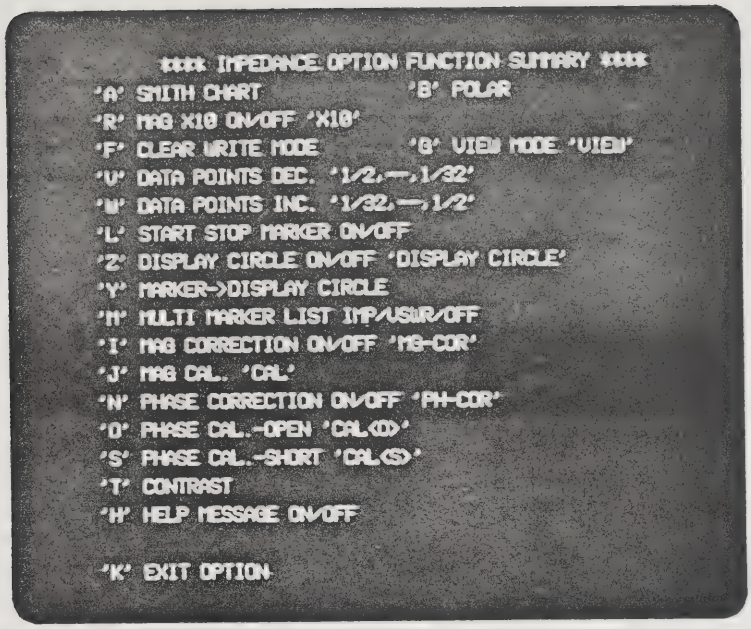


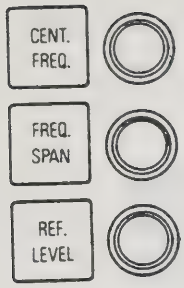
Fig. 9-27 Key function listing for impedance measurement mode

The letter enclosed in quotation marks (' ') denotes the character provided on the right side of each key, and the letters given in right denote the relevant function. Pressing the H key again restores the original display image, while maintaining all the setup parameters intact.

9-4-3. Measurement Examples

This paragraph provides an example of application of the impedance measuring option, with bandpass filter response measurement as an example.

(1) Connect the DUT (filter) across the TRACKING GENERATOR OUTPUT and INPUT-1 of the TR4172, then set up the necessary measuring parameters (such as center frequency, frequency span, etc.) observing the pass-band response in the normal mode.



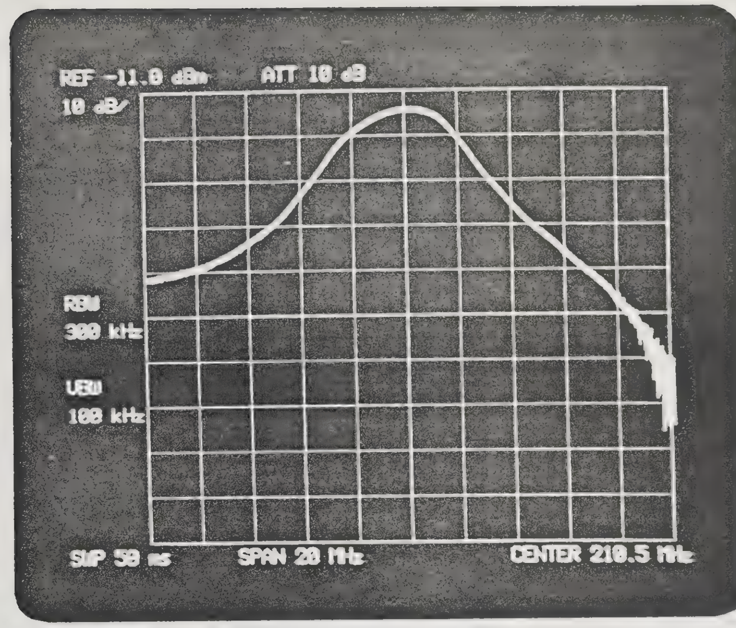


Fig. 9-28 Pass-band characteristic of band-pass filter

(2) Next, connect the VSWR bridge to the TR4172 instead of the DUT (filter) as shown in Figure 9-1, with the DUT left disconnected from the bridge. Activate a marker, and press the MARKER → REF key to position the signal response peak to the reference level.

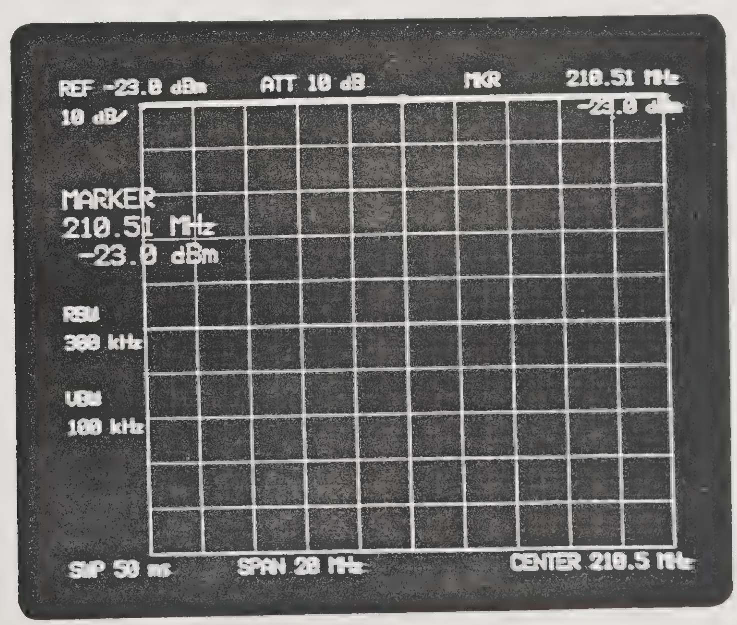


Fig. 9-29 Positioning the signal response peak to the reference level

(3) Connect the DUT to the VSWR bridge. The return loss of the DUT can be read out as the level difference from the reference level.

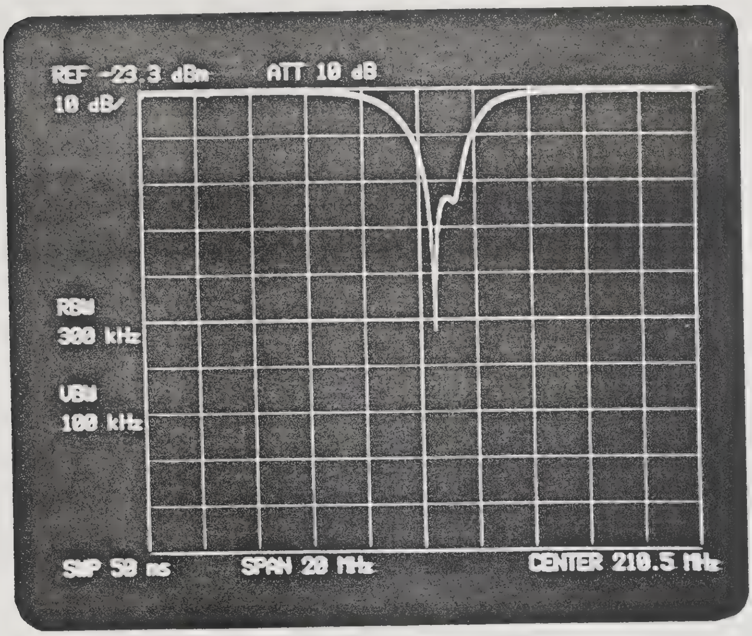


Fig. 9-30 Measurement of DUT return loss

(4) Disconnect the DUT from the VSWR bridge, and instead connect an open or shorting device to the DUT terminals on the bridge. (If the terminals are simply opened, the connector capacity will cause an error; therefore, it is preferable that a highquality open or shorting device be connected across the terminals.) Perform calibration according to the instructions in 9-3-2 and 9-3-3. Calibration in the impedance measurement mode is time consuming. To reduce this time, set the sweep time at a relatively small value to make course calibration, then set sweep time to the optimum value to perform fine calibration. It is also recommended that the V (POINTS DEC.) key be pressed several times in advance to reduce the number of data points and hence save calibration time. The calibration time may be further reduced if course calibration is done in the normal measurement mode (not in the impedance measurement mode) by utlizing the relationship shown in Figure 9-3.

(5) After completing calibration, connect the DUT to the DUT terminals on the VSWR bridge, allowing measurement on a Smith chart. While in the normal measurement mode frequencies can be read from the scale, in the normal measurement mode, on the Smith chart they are read by markers. It is recommended therefore, to use the Multi Marker mode in the impedance measurement mode. In the impedance measurement mode as well, up to 10 multi markers are available, which will be useful for photographing or copy to the plotter.

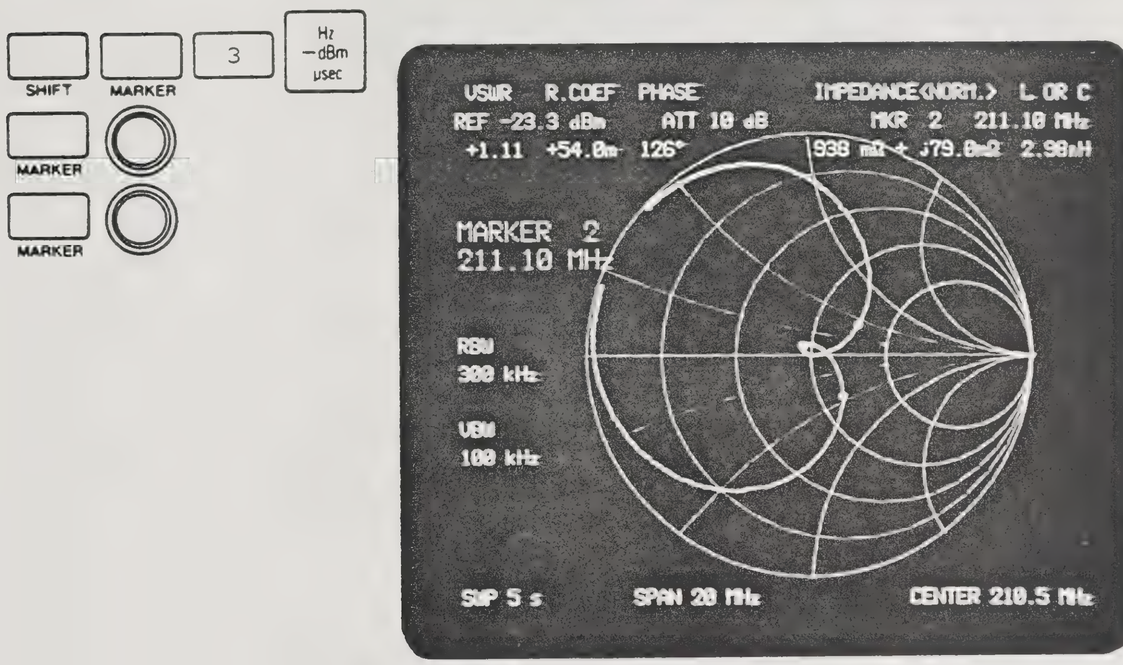


Fig. 9-31 Multi marker mode

(6) To clear the impedance measurement mode, press the K (EXIT) key. The return loss display can be restored by pressing the NORMAL key.

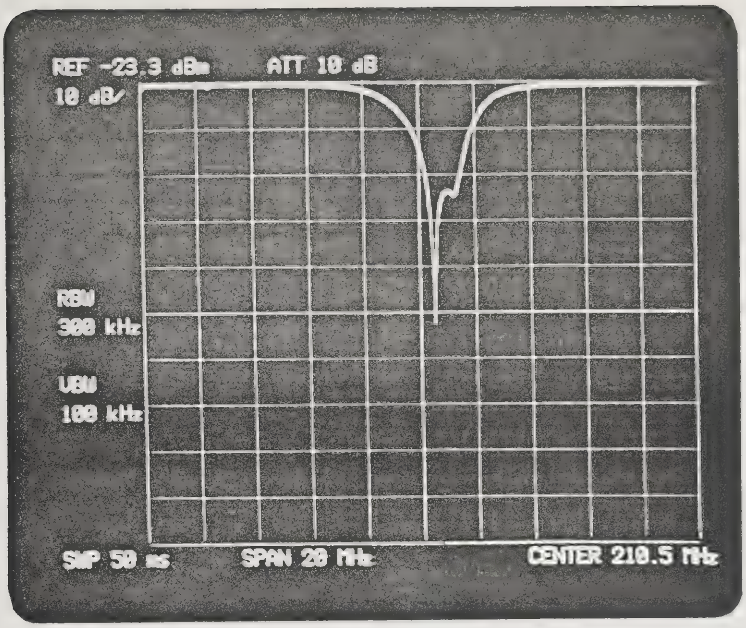


Fig. 9-32 Clearing the impedance measurement mode

9-4-4. Notes on Impedance Measurement

(1) The following keys have the same functions in both normal and impedance measurement modes:

. Function keys
. Data keys
. TG LEVEL key
. INPUT ATT and AUTO keys
. LABEL, MKR OFF with SHIFT (LABEL CLEAR) keys
. MARKER and MARKER OFF keys
. ▲ (delta marker) key
. MARKER with SHIFT (multi marker) key
. GROUP DELAY with SHIFT key (group delay offset)
. PHASE with SHIFT key (phase offset)
. LABEL and Q with SHIFT keys (plotter)
. MASTER RESET key
. LCL key
. INPUT-1 (AC) key
. INPUT-1 (DC) key
. INPUT-2 key

All parameters set up with these keys are left intact, whether the impedance measurement mode is set or not. All other keys are assigned functions unique to the impedance measurement mode, or are made inoperative. In either case, the lamps in those keys are off.

The impedance measurement mode can be entered whether the preceding mode was the amplitude, phase, or group delay mode or the preceding scale was linear or logarithmic. When the impedance measurement mode is cleared, the original mode and scale are restored. For example, if the impedance measurement mode is selected with amplitude measurement of 5 dB/div. in the normal mode, the amplitude measurement mode at 5 dB/div. is restored when the impedance measurement mode is cleared. Similarly, if the phase measurement mode of 80 deg/div. was selected before the impedance measurement mode was selected, the same phase measurement mode of 80 deg/div. is restored when the impedance measurement mode is unset.

(2) When duplicating the display information on a plotter, press the SHIFT, LABEL, Q, and 1 keys in the impedance measurement mode. All impedance measurement control functions can be remotely controlled over the GPIB. For example, an SH LA 0 sent from the controller to the instrument puts the instrument in the impedance measurement mode. The command PS PS causes the number of data points to be reduced to one-fourth, and the command BW clears the impedance measurement mode.

(3) In the impedance measurement mode, display data is stored over 500 memory locations beginning from address C818. The scale data is stored in a memory area beginning from address C018. Each data point is represented by an orthogonal coordinate point of (x, y), and is stored as X1, Y1, X2, Y2, X3, Y3, and so on in ascending order.

Data should be taken out in decimal form by pressing the VIEW A key. Meaningful data is between 0 and 1023. Data beyond 1023 is blanking data, which should be ignored.

To convert the outer circumference of the scale into data (xn, yn) which represents a circle with its center located at (0, 0) and a radius of 1, use the following conversion formulas:

$xn = (x - 512)/500$, $yn = (y - 512)/500$

A basic programming example using the Hewlett Packkard Model 9826 Controller is shown below. After executing this program, measurement information is plotted on the 9826 display.

```
10     GINIT
20     GRAPHICS ON
30     A=1.024
40     WINDOW -A*4/3.A*4/3.-A.A
50     OUTPUT 701:"RDC8180040 TO"
60     PEN -1
70     FOR I=1 TO 500
80     ENTER 701:X
90     ENTER 701:Y
100    DRAW (X-512)/500.(Y-512)/500
110    PEN 1
120    NEXT I
130    END
```

Figure 9-33, 34, 35 show plotting examples of Smith chart, Enlarged Smith chart, and polar coordinate, respectively.

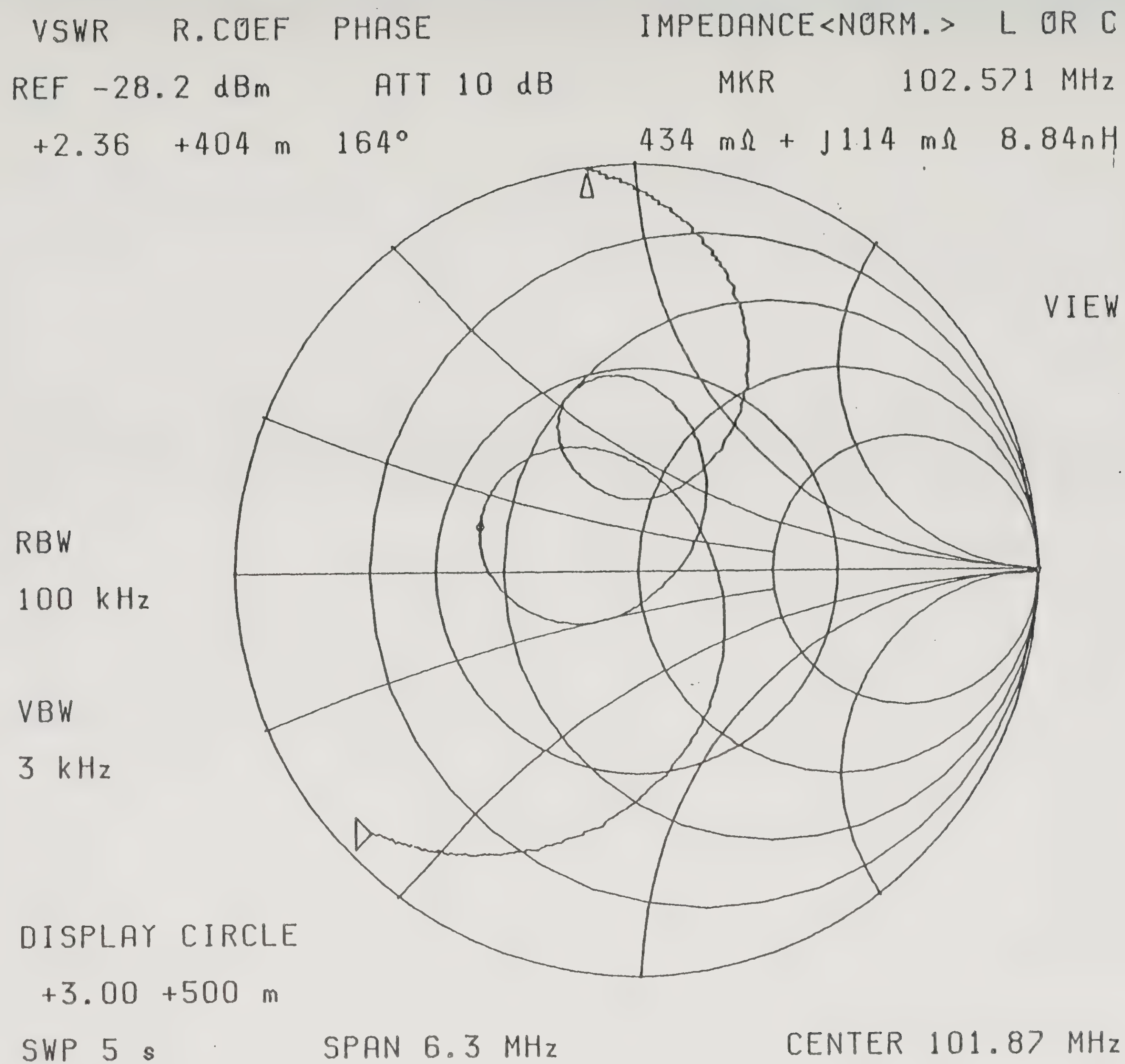


Fig. 9-33 Smith chart plotted

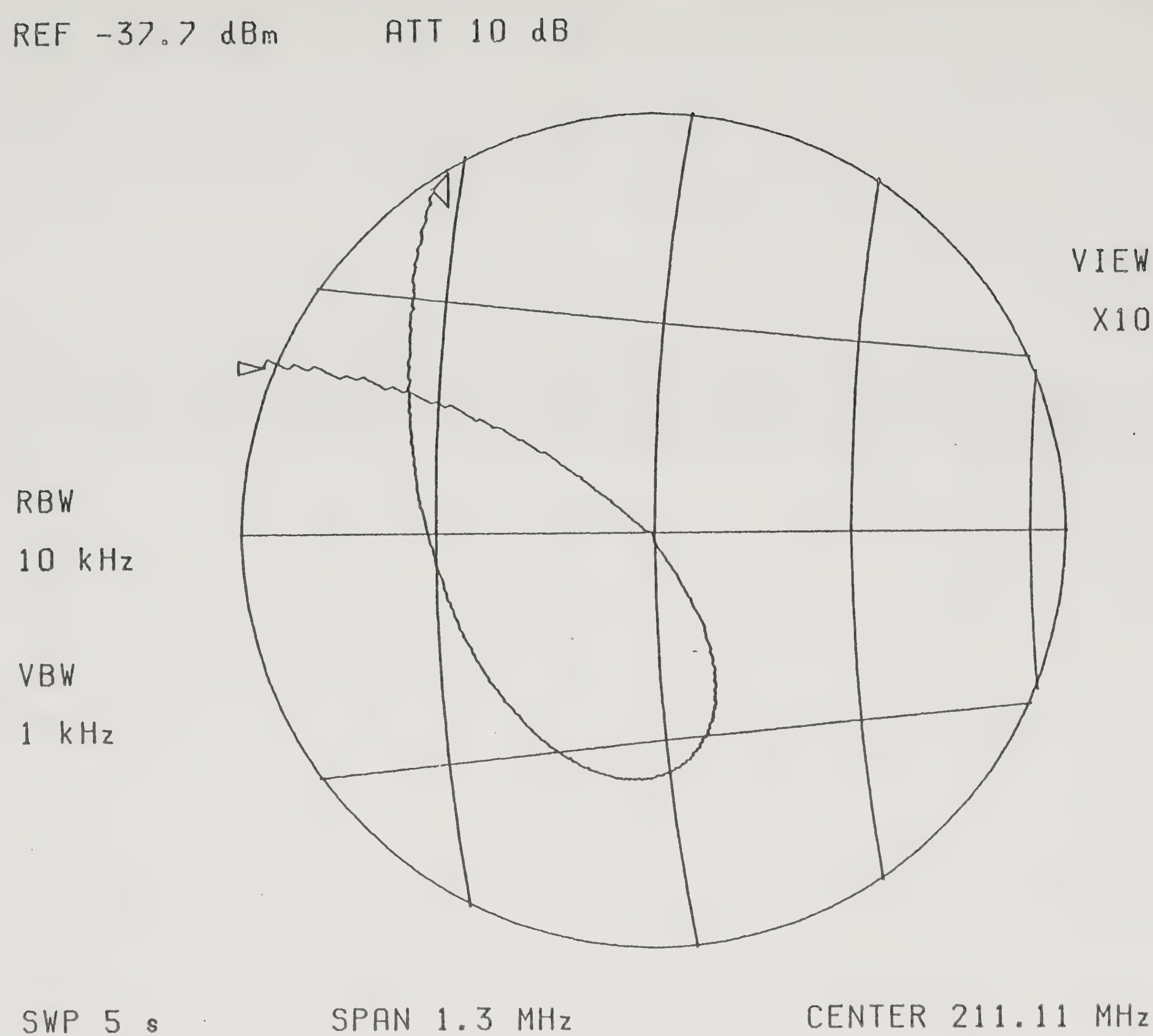
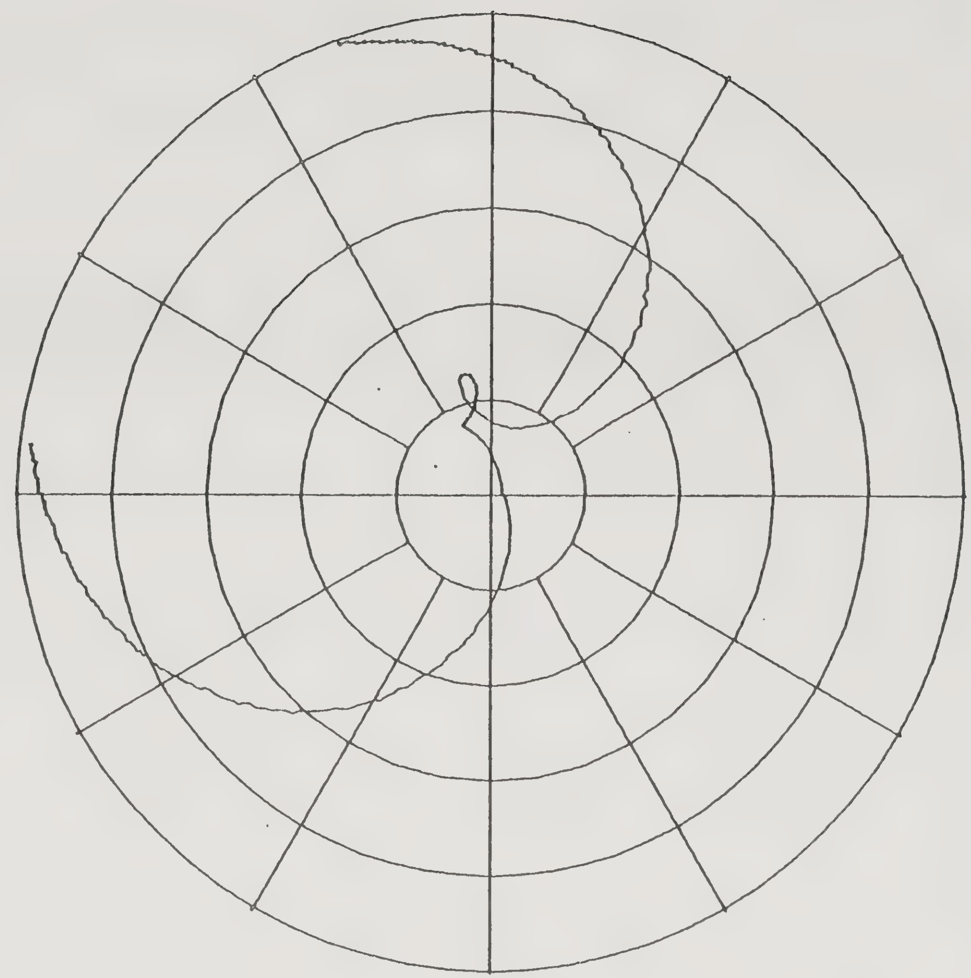


Fig. 9-34 Enlarged Smith chart plotted



oordinate display plotted

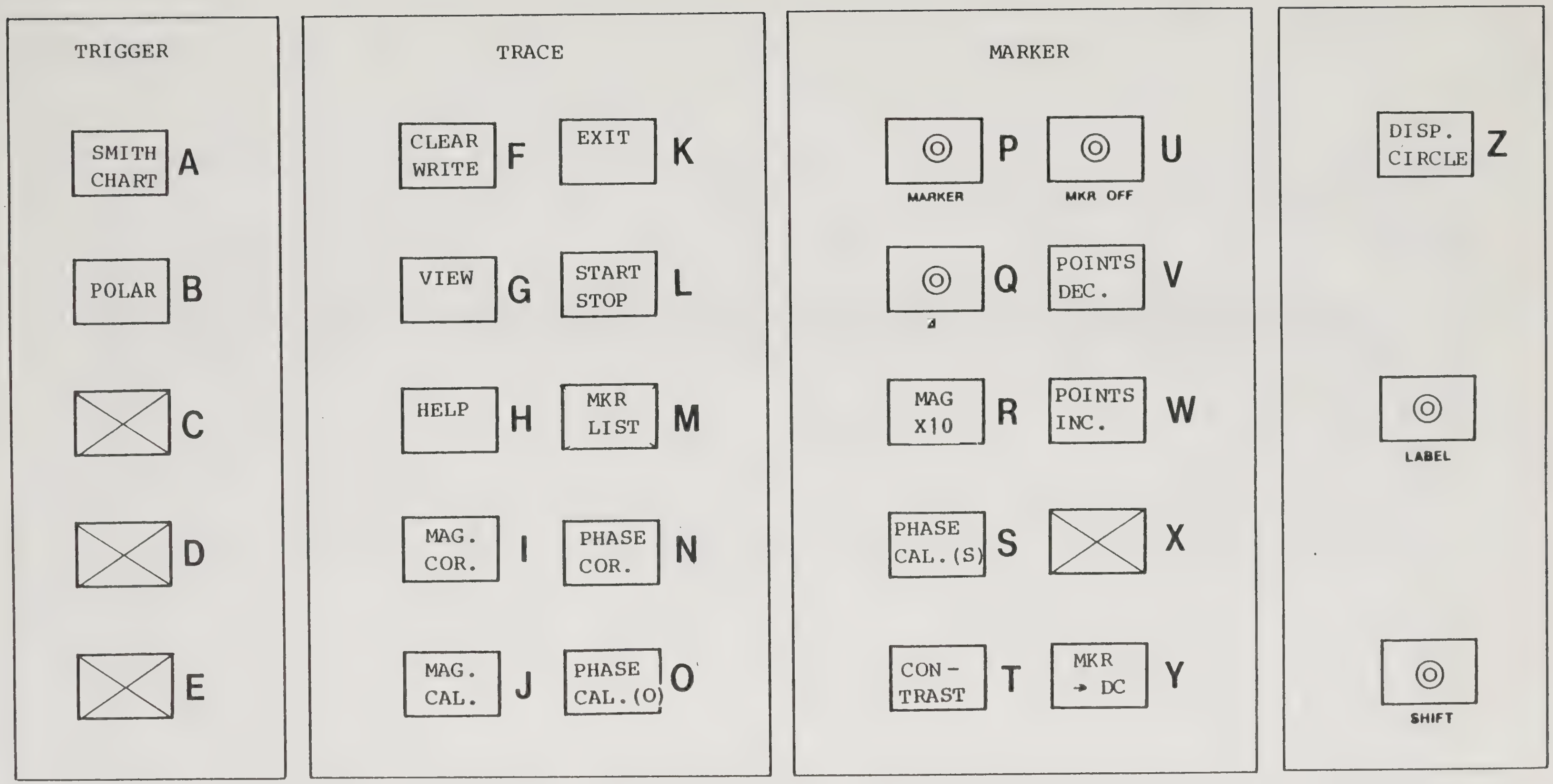
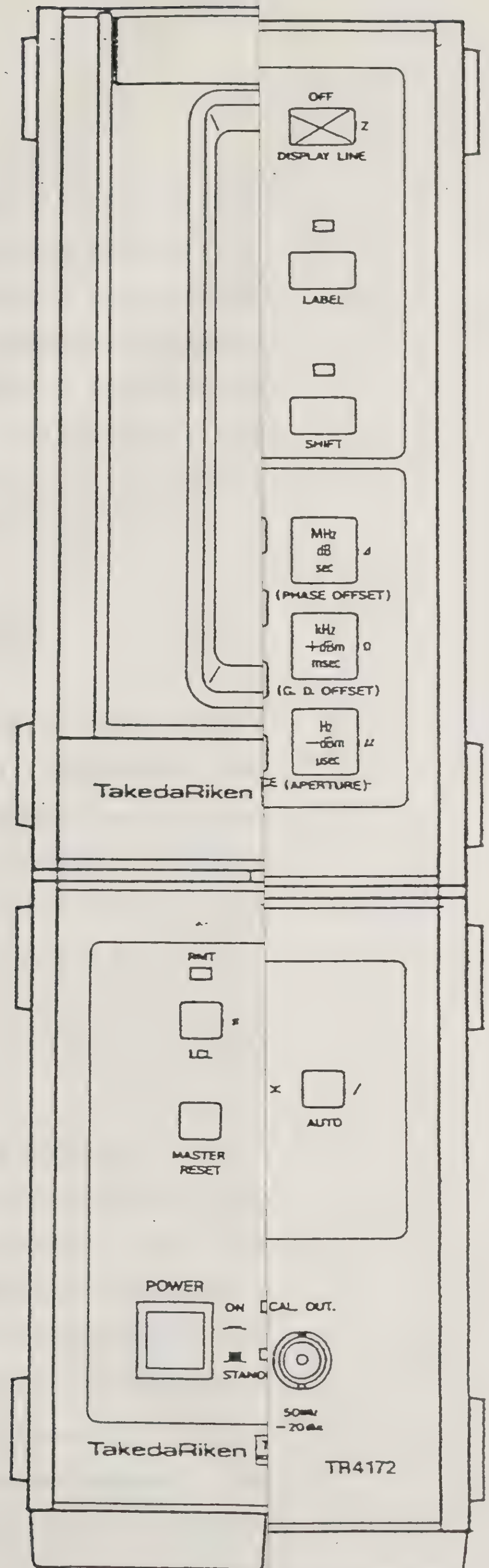


Fig. 9-36 Key functions unique to the impedance measurement mode (Keys marked ☒ are not operative. Keys marked ◎ have their original functions.)


OFF
DISPLAY LINE
LABEL
SHIFT
MHz
dB
sec
(PHASE OFFSET)
kHz
+dBm
msec
(G. D. OFFSET)
Hz
-dBm
usec
(APERTURE)
TakedaRiken
RMT
LCL
MASTER
RESET
AUTO
POWER
ON
CAL. OUT.
TakedaRiken
TR4172

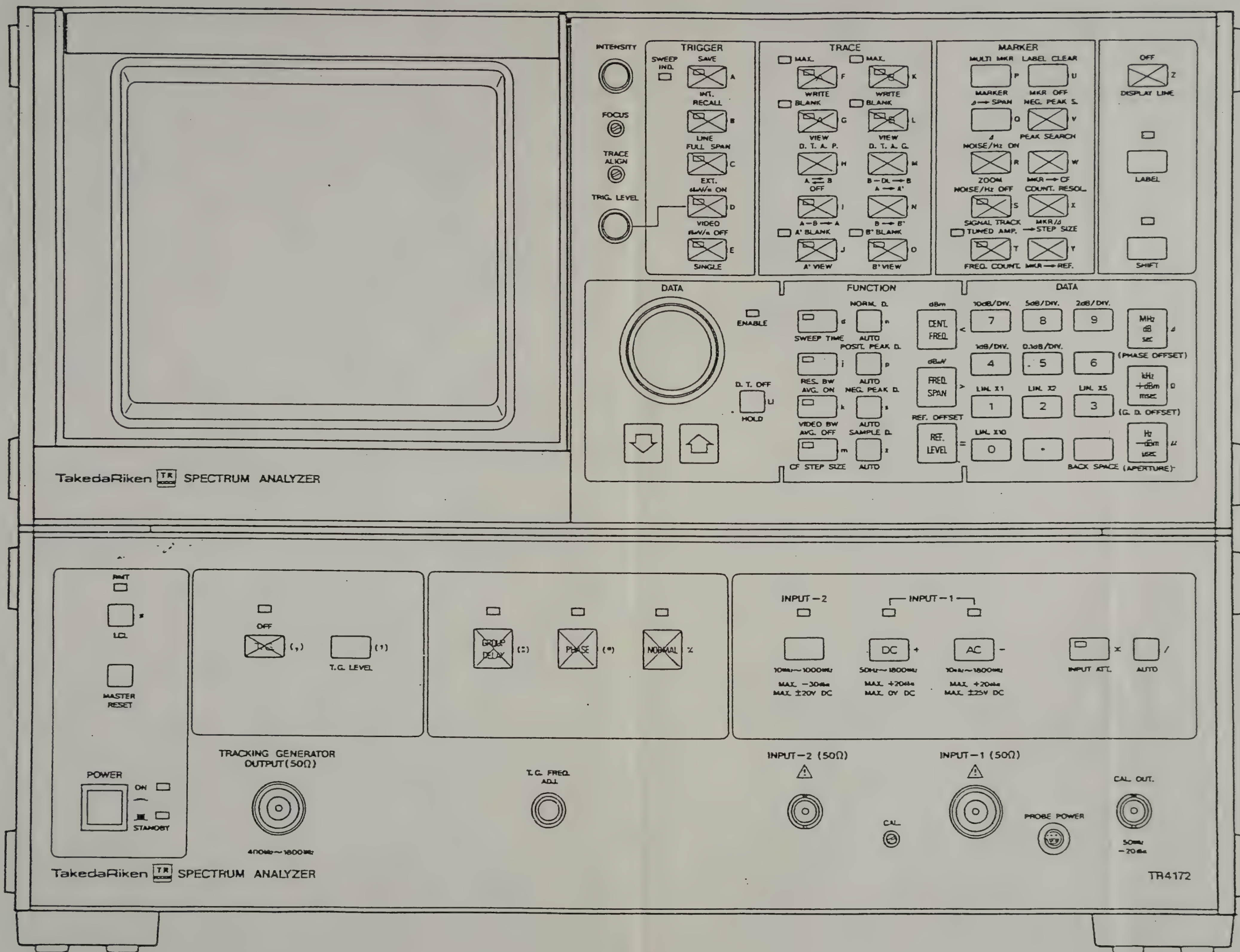


Fig. 9-37 Keys having different functions in the impedance measurement mode. (All keys other than those marked ⊠ have their original functions.)

SECTION 10

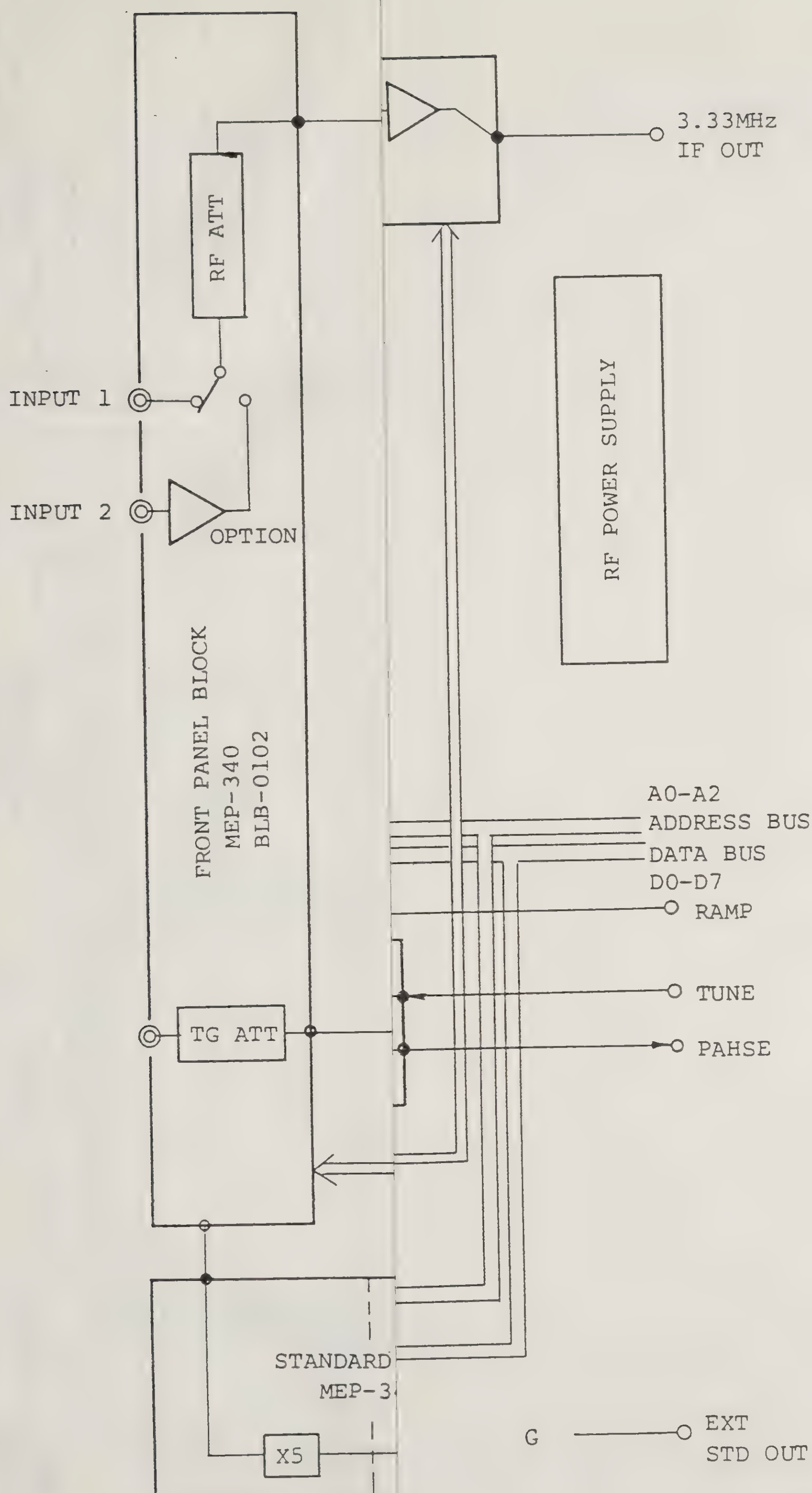
PRINCIPLES OF OPERATION

10-1. GENERAL

This section provides brief descriptions of the configuration of the TR4172 Spectrum Analyzer and its functional divisions, and some detailed explanations of the operation theories of each of these divisions. Detailed schematic diagrams are given in the back of this manual. See the Glossary in the back of this manual for the meanings of technical terms and special parts referred to in this section.
This section is designed primarily for the reference for engineers and electronics technicians.

10-2. CONFIGURATION

The TR4172 Spectrum Analyzer is a heterodyne receiver. It converts input signal frequency into a given intermediate frequency (IF) and uses this IF signal for all subsequent signal processing, information display, and level readout.
The TR4172 contains a tracking generator (signal generator generating a frequency identical to the input signal frequency) and a frequency counter, which provides phase measurement, group-delay measurement, and micro-level signal frequency measurement capabilities.
An internal microprocessor controls all measurement condition setup, data storage, display, and display information enlargement processing. Control access or data read from an external controller can be accomplished over the GP-IB.
Figure 10-1 and 10-2 show outlines of the instrument configuration. The structure of individual functional divisions will be described in 10-3 and subsequent paragraphs.
The TR4172 consists of an RF section and a display section.
The RF section converts input signals into IF signal. It consists of a Front panel; YIG oscillator; Standard, RF, 1st local PLL, 3rd local, TG, counter, and Power supply blocks; and other control boards (ATT I/O, YIG I/O, and 3rd local I/O boards). The final IF output of the RF section is 3.33333 MHz.


3.33MHz
IF OUT
RF ATT
RF POWER SUPPLY
INPUT 1
INPUT 2
OPTION
FRONT PANEL BLOCK
MEP-340
BLB-0102
A0-A2
ADDRESS BUS
DATA BUS
D0-D7
RAMP
TUNE
TG ATT
PAHSE
STANDARD
X5
G
EXT
STD OUT

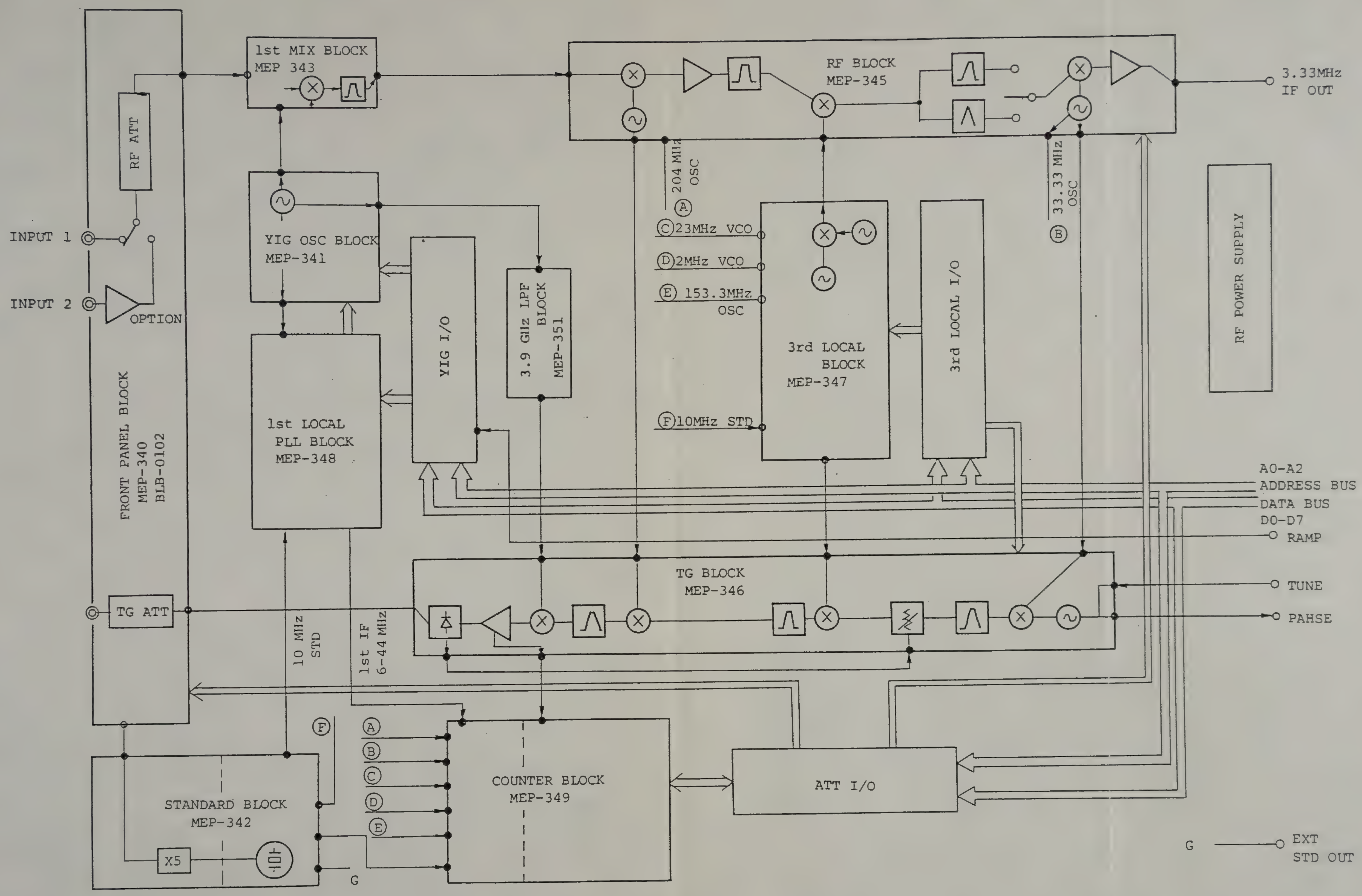


Fig. 10-1 TR4172 Block Diagram-1 RF Section

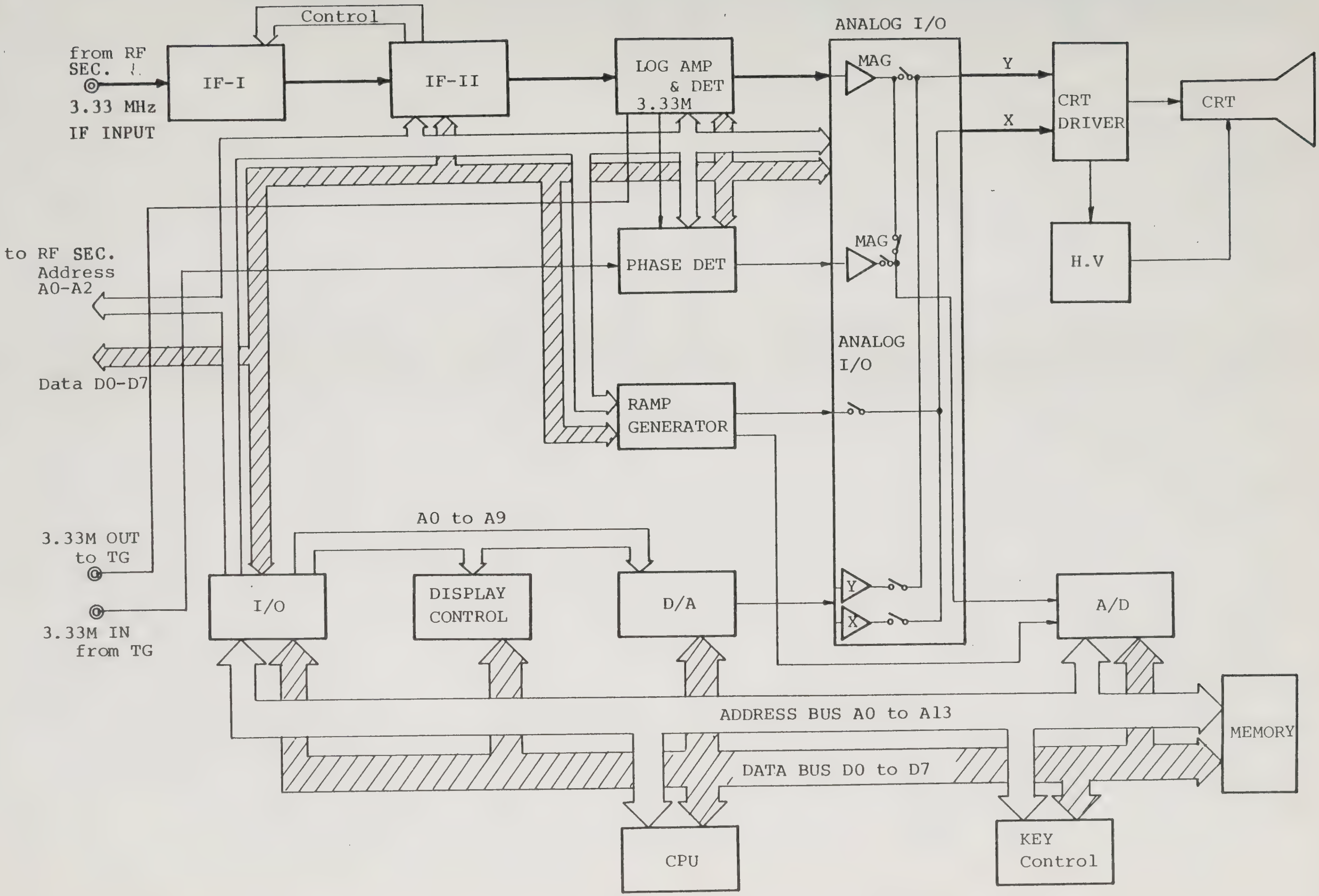


Fig. 10-2 TR4172 Block Diagram-2 Display Sect:

The display section receives the IF signal output from the RF section and performs various arithmetic and logical processing on the signal before displaying it on the CRT. It contains IF, Log amp., Phase, high voltage, CRT driver, and Display power blocks; and several processing boards, such as CPU, Memory, A-D converter, D-A converter, I/O & GP-IB, Ramp Generator, Display Control, and Analog I/O boards.

The display section breaks down the input IF signal into several components in its IF section, performs logarithmic compression on these components in the Logarithmic block, then converts the signal into DC. It then converts this DC level into the corresponding digital code, processes and stores the digitally-coded data, converts it into various forms according to selected functions, and converts it again into an analog signal before delivering it to the CRT for measurement information display.

The following paragraphs describe the functions and operations of each section.

10-3. FUNCTIONAL BLOCK OPERATIONS IN THE RF SECTION

10-3-1. Sub-Panel Block (MEP-340) (Circuit diagram No. 41)

(1) RF ATT. and DC-AC switching

A DC-AC mode selector switch and an attenuator convering an attenuation range of 0 to 50 dB are contained in the same housing.

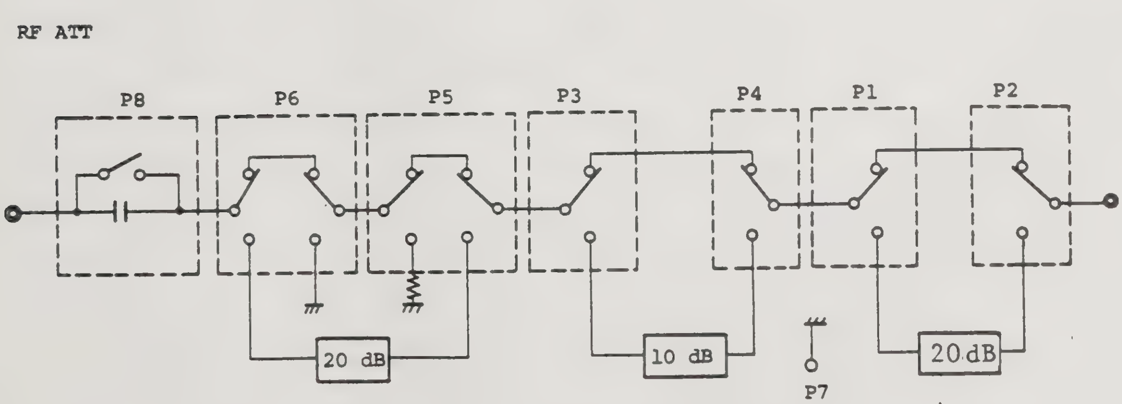


Fig. 10-3 Internal configuration of RF attenuator

Table 10-1 Control data for AC-DC switch and RF attenuator

	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
0dB	0	1	0	1	1	0		
10 dB	0	1	1	0	1	0		
20 dB	1	0	0	1	1	0	GND	
30 dB	1	0	1	0	1	0		
40 dB	1	0	0	1	0	1		
50 dB	1	0	1	0	0	1		
AC/DC								0/1

The control data is held by the Attenuator I/O board (BGN-010220) and is coupled to the attenuator assembly via the Attenuator Driver board (BLB-010223).

(2) TG Attenuator

The TG Attenuator has the same configuration and control requirements as the RF Attenuator. However, it does not contain P8.

(3) Preamplifier BLB-010233 (Circuit diagram No. 43)

The Preamplifier is used when Option 02 is installed in the instrument. It has a gain of +25 dB over a frequency range from 10 MHz to 1 GHz for micro-level signal measurement. The power to the Preamplifier is activated only when the front INPUT-2 key is activated.

(4) Attenuator Driver (BLB-010223) (Circuit diagram No. 42)

This board provides control data to the RF attenuator, AC-DC selector switch, TG attenuator, and preamplifier power supply. All data lines from this board are connected to the ATT I/O board, with the exception of the Power On Data line.

10-3-2. 1st Mixer Block (MEP-343) (Circuit diagram No. 50)

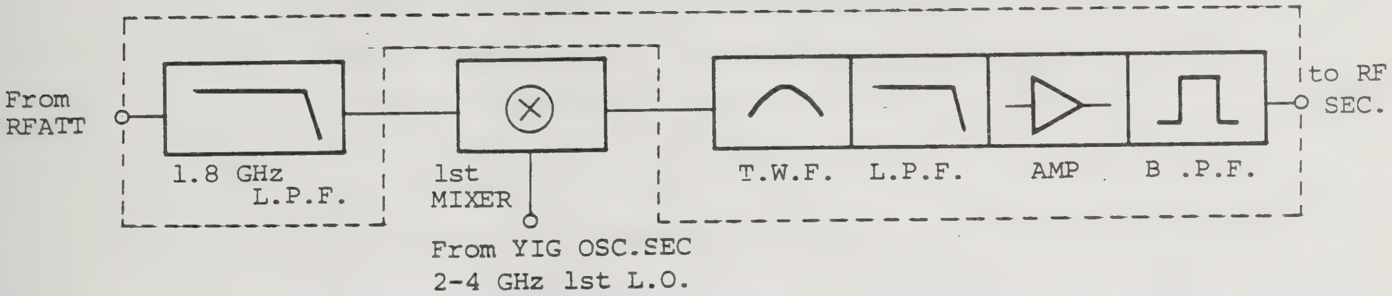


Fig. 10-4 1st Mixer block diagram

The 1st mixer block contains a first mixer and input/output interface.

(1) 1.8 GHz low-pass filter (LPF)
The 1.8 GHz LPF consists of balanced microstrip lines which constitute a 15-stage Chebyshev filter array.

(2) First mixer BTB-010136 (Circuit diagram No. 51)
Double-balance mixer whose characteristics significantly affect the frequency response flatness, higher harmonic distortion, and gain compression level. The diode bridge uses eight Schottky diodes.

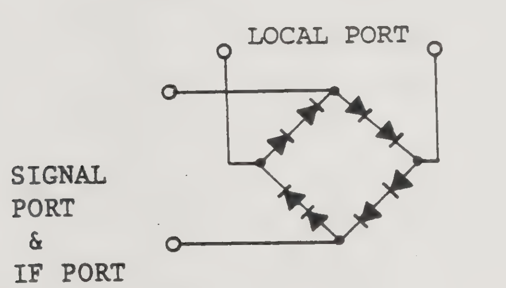


Fig. 10-5 First mixer

Input signal frequency ranges from 50 Hz to 1800 MHz, while local oscillator (first local oscillator) frequency ranges from 2.046 to 3.846 GHz (+20 dBm or more), and the resulting intermediate frequency is 2.046 GHz.

(3) Interface

The interface amplifies only the 2.046 GHz component out of the IF signal output of the first mixer to prevent spurious interference by other frequencies. It consists of a band-pass filter and other components (see Figure 10-4), and has a minimum gain of 0 dB.

10-3-3. YIG Oscillator Block (MEP-341) (Circuit diagram No. 44)

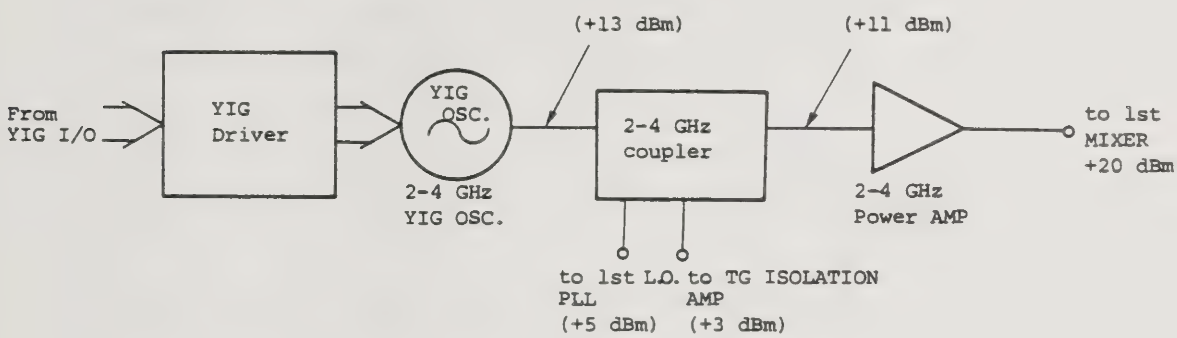


Fig. 10-6 YIG Oscillator block diagram

(1) YIG Oscillator

The first local oscillator in the TR4172 is a YIG oscillator covering an output frequency range from 2 to 4 GHz. The YIG oscillator is essentially a sweep oscillator characterized by output purity, low hysterisis, and high linearity. The output level at its output terminal is more than +13 dBm over the entire frequency range.

(2) 2 to 4 GHz coupler

This coupler is used to branch the YIG OSC output into the TG and first local phase lock loop blocks. Each branching path has coupling losses of -10 dB and -8 dB respectively, and the resulting output levels at the coupler's outputs are +3 dBm and +5 dBm respectively. The output to the first mixer has a level of +11 dBm.

(3) 2 to 4 GHz power amplifier

The power amplifier amplifies the output of the coupler to +20 dBm or more, the level required for the local oscillator input to the first mixer. The maximum supply voltage to the power amplifier is +10 Vdc.

(4) YIG OSCILLATOR DRIVER BLC-010224 (Circuit diagram No. 45)

The YIG oscillator contains main and FM drive coils. Its output frequency is controlled by driving these coils according to the data furnished from the YIG I/O board (BGN-010219). The controllable ranges for each coil are as follows:

Main coil	Span > 10 MHz:	Sweep, tune
	Span < 10 MHz:	Fixed
FM coil	10 MHz ≥ Span > 500 kHz:	Sweep, tune
	Span ≤ 500 kHz:	Tune fixed, PLL voltage

These ranges are controlled by the CPU via the YIG I/O board's control line.

10-3-4. Standard Block (MEP-342) (Circuit diagram No. 46)

(1) Timebase BLB-010134 (Circuit diagram No. 47)

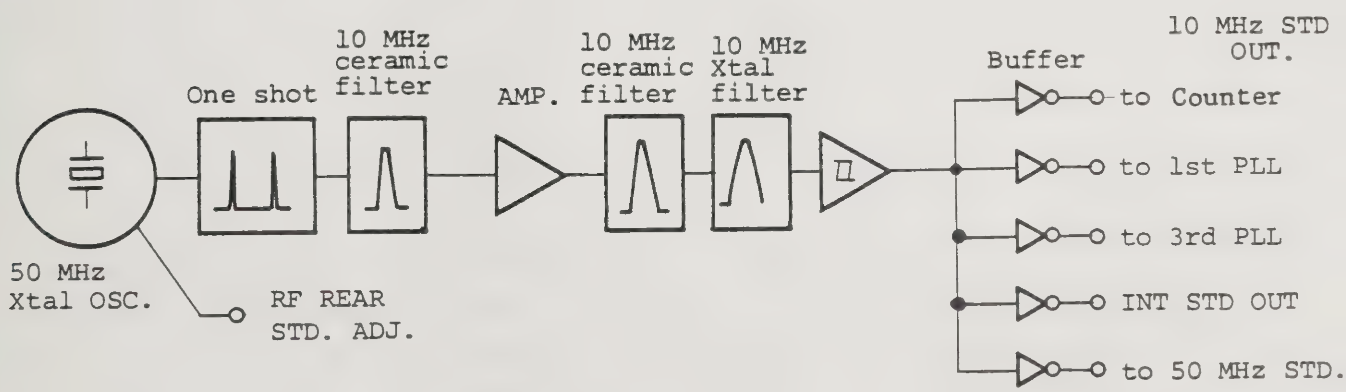


Fig. 10-7 Timebase generator block diagram

The timebase generator generates a 5 MHz timebase signal (TTL conpatible) by its quartz-controlled oscillator, whose output is first waveform shaped, then converted into a 10 MHz signal by ceramic filters and amplifier. The output of the second ceramic filter goes through a 10 MHz crystal filter to reject noise components before being delivered to each block in TTL compatible level.

The output of the timebase oscillator can be directly tested at the INT. STD OUTPUT (J4) terminal on the rear of the instrument.

(2) 50 MHz Standard BLB-010135 (Circuit diagram No. 48)

A 50 MHz calibration signal for level and frequency reference is generated by 50 MHz Standard and output to the CAL. OUT. connector on the front panel. Its level is -20 dBm ±0.3 dB, and its frequency stability depends on that of the timebase master crystal oscillator.

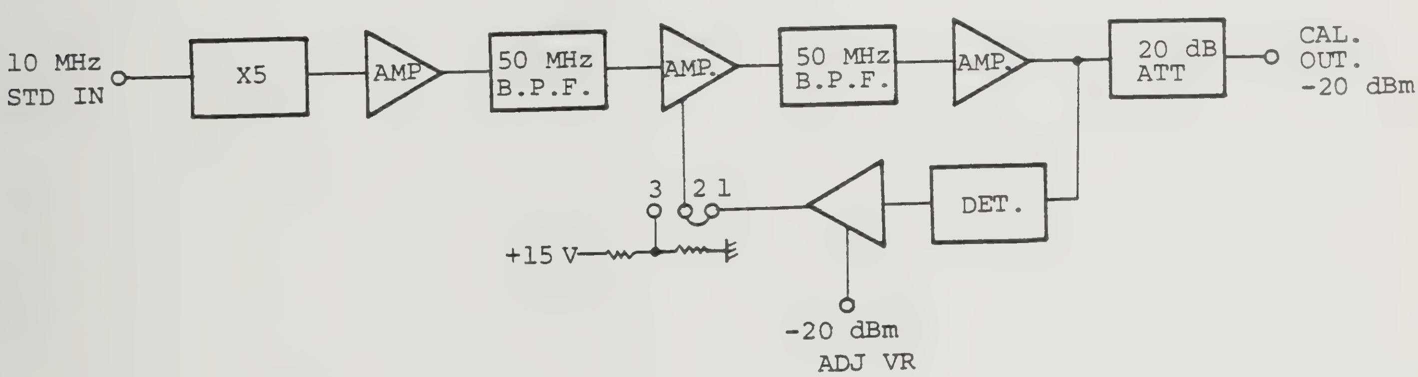


Fig. 10-8 50 MHz Standard

The generator multiplies the 10 MHz TTL input from the timebase oscillator by five into 50 MHz, and then rejects unnecessary frequency components by the following band-pass filters. To stabilize the output level, an auto level control (ALC) loop is formed around the second and third amplifiers.

10-3-5. RF Block MEP-345 (Circuit diagram No. 52)

The RF block consists of a second local oscillator, fourth local oscillator, second mixer, third mixer, fourth mixer, IF gain control amplifier, and so forth. It converts down the 2.05 GHz IF signal form the first mixer block and outputs the final IF signal of 3.33 MHz. Figure 10-9 shows the block diagram of the RF block.

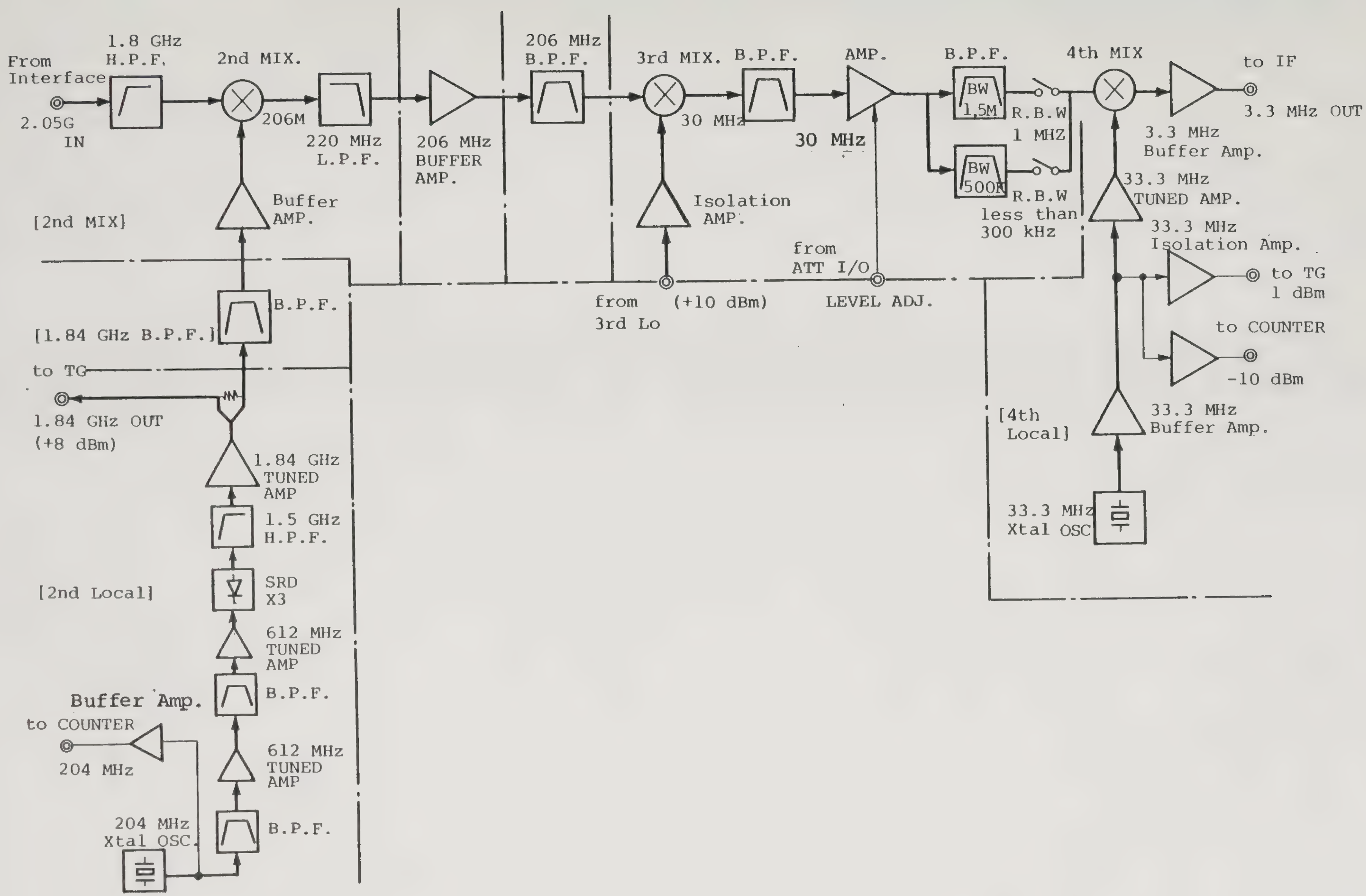


Fig. 10-9 Block diagram of the RF block

(1) 2nd local oscillator

The 2nd local oscillator provides an output frequency of 1.84 GHz, which is obtained by multiplying a 204.4 MHz output of the quartz-controlled oscillator by nine. It furnishes its output to the second mixer and TG 2nd local oscillator.

The quartz oscillator output of 204.4 MHz is first multiplied by 3.

The output of the multiplier goes through a buffer amplifier and a band-pass filter (BPF) to boost the signal level to more than +10 dBm. It is then applied to a step recovery diode to generate the 1.84 GHz frequency component. The output of the diode goes through a high-pass filter (HPF) and a 1.84 GHz tuned amplifier before it is branched into the two paths to the second mixer and TG. The output to the second mixer goes through a 1.84 GHz BPF and 1.84 GHz tuned-amplifier before being coupled to the mixer. Part of the 204 MHz quartz oscillator output is coupled to the counter block via a buffer amplifier. This output is counted by the CPU and used for center frequency setup or 2nd local oscillator maintenance.

(2) Second mixer

The second mixer is the single balanced type. It mixes the first IF signal of 2.046 GHz (from the first mixer block) with the second local oscillator output of 1.84 GHz to create the second IF signal of 206 MHz. This second IF signal is output via a 220 MHz LPF.

(3) Second IF tuned amplifier and BPF

The second IF tuned amplifier compensates for losses in the second mixer and 206 MHz BPF of improve signal-to-noise ratio. It has a gain of 14 dB, and deals with the highest signal in the TR4172's signal paths. The 206 MHz BPF is a 4-stage herical bandpass filter.

(4) Third mixer

The third mixer mixes the second IF signal of 206 MHz with the third local oscillator output to create the third IF signal of 30 MHz. It is a high-level, double-balanced mixer using diode resistance.

(5) Level correction amplifier

Level correction is accomplished by the CAL screwdriver control on the front panel and the sweep signal to compensate to change the gain of this amplifier.

(6) 30 MHz BPF switching circuit

This circuit switches the 30 MHz BPF signal paths between RBW 1 MHz, RBW 300 kHz or below to eliminate unnecessary frequency components.

(7) Fourth local oscillator and 33.33 MHz quartz-controlled oscillator

The fourth local oscillator is a colpitts type quartz-controlled oscillator. The output is branched via a buffer amplifier into three paths to the 4th local oscillator, TG, and counter. The output to the 4th local oscillator is further amplified for high-level mixing before being coupled to the fourth mixer.

(8) Fourth mixer

The fourth mixer mixes the third IF signal of 30 MHz with the fourth local oscillator output of 33.3 MHz to provide the final IF signal of 3.33 MHz.

Figure 10-10 shows RF Section level diagram.

10-3-6. 1st Local PLL Block (MEP-348) (Circuit diagram No. 64)

The YIG oscillator output may be affected by noise interference when the frequency span is narrowed down. The first local oscillator PLL block stabilizes this YIG oscillator (first local OSC) output against noise interference by means of the PLL technique. Figure 10-11 shows the block diagram. The PLL block is activated when a frequency span of 500 kHz or less is selected.

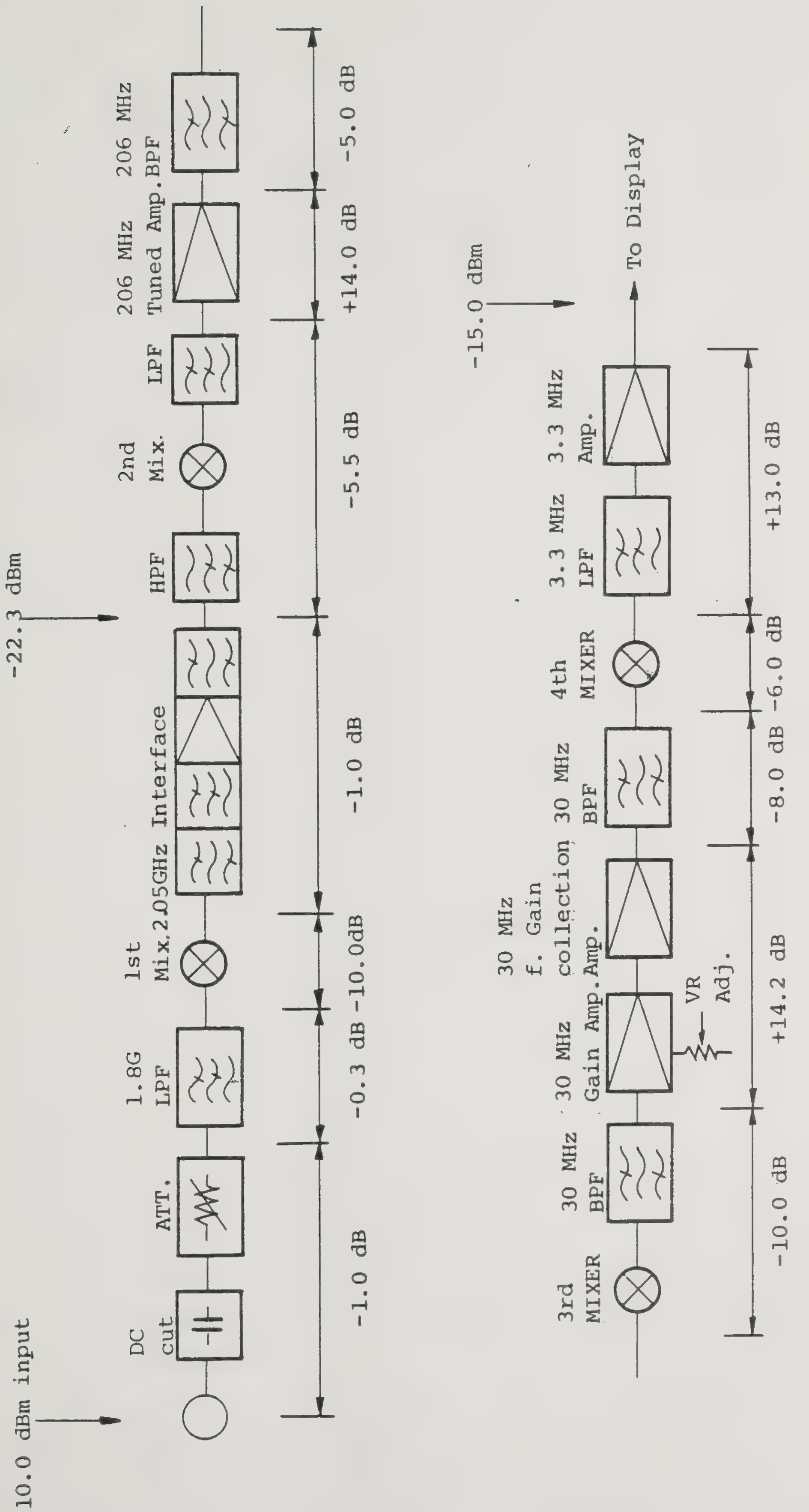


Fig. 10-10 RF section level diagram

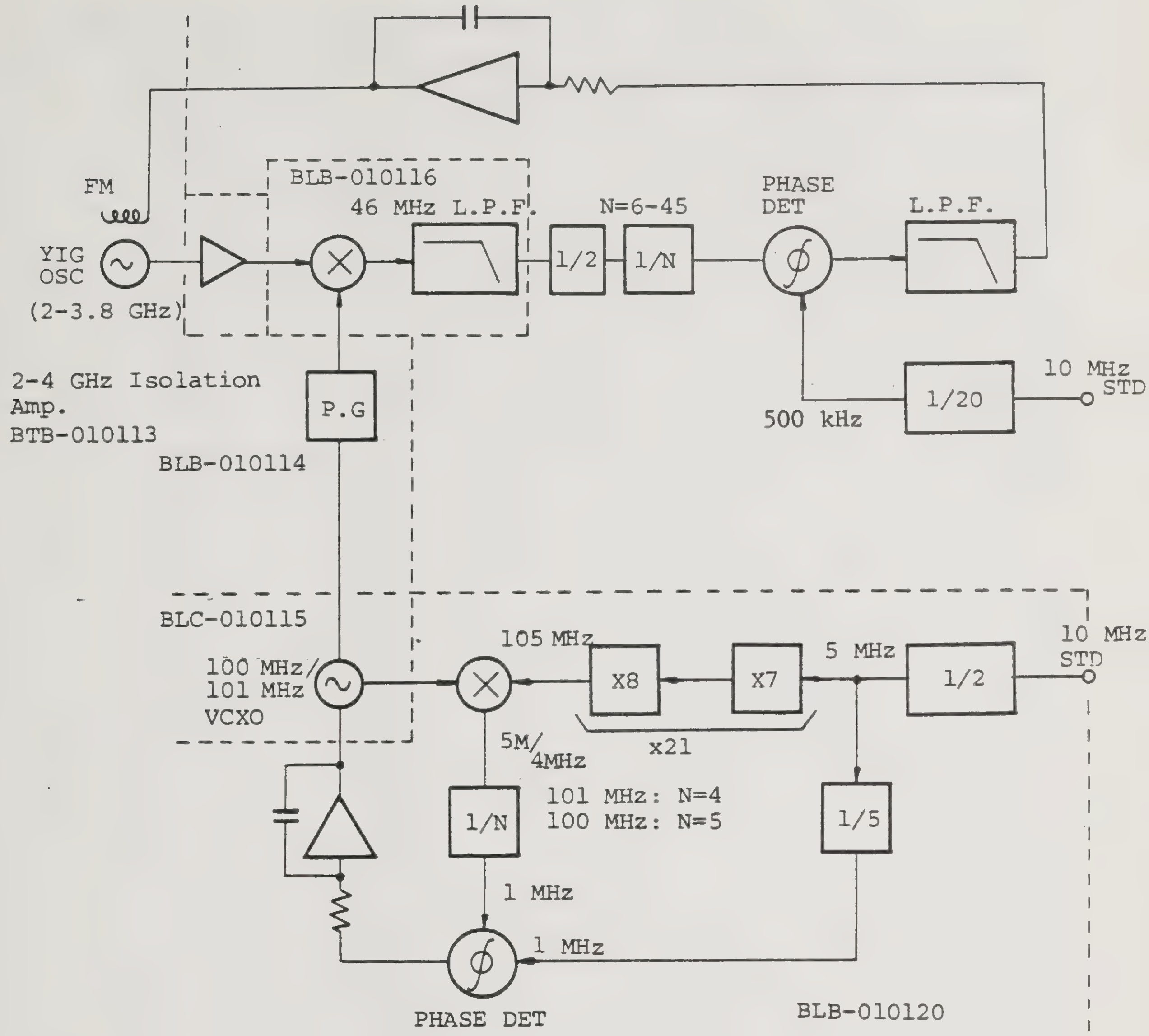


Fig. 10-11 First Local PLL block diagram

(1) Isolation amplifier BTB-010113x01/02 (Circuit diagram No. 65)
Buffer amplifier for the first local signal of 2-4 GHz furnished from the YIG oscillator block. It consists of a three-stage transistor amplifier and three 3-dB attenuators to provide electrical isolation between the 100/101 MHz signal and the YIG section.

(2) 100/101 MHz oscillator BLC-010115 (Circuit diagram No. 67)

The phase locked loop (PLL) performs phase comparison between the output of a given oscillator and that of a reference oscillator to "lock" the frequency of the former oscillator to that of the reference oscillator. The first PLL block in the TR4172 uses two quartz-controlled oscillators of 100 MHz and 101 MHz each, for the reference oscillators. One of the two reference oscillators is selected depending on center frequency setting. Figure 10-12 shows the selection VS center frequency. The two oscillators are necessary to eliminate the dead zone of the IF signal output between 2 and 4 GHz and to permit formation of phase locked loop at any frequency.

The outputs of these crystal oscillators are input to the 100/101 MHz PLL networks (described later) to construct another phase locked loop which reference the 10 MHz time base frequency. The outputs of the two oscillators are amplified to more than +20 dBm and coupled to the first PLL pulse generator.

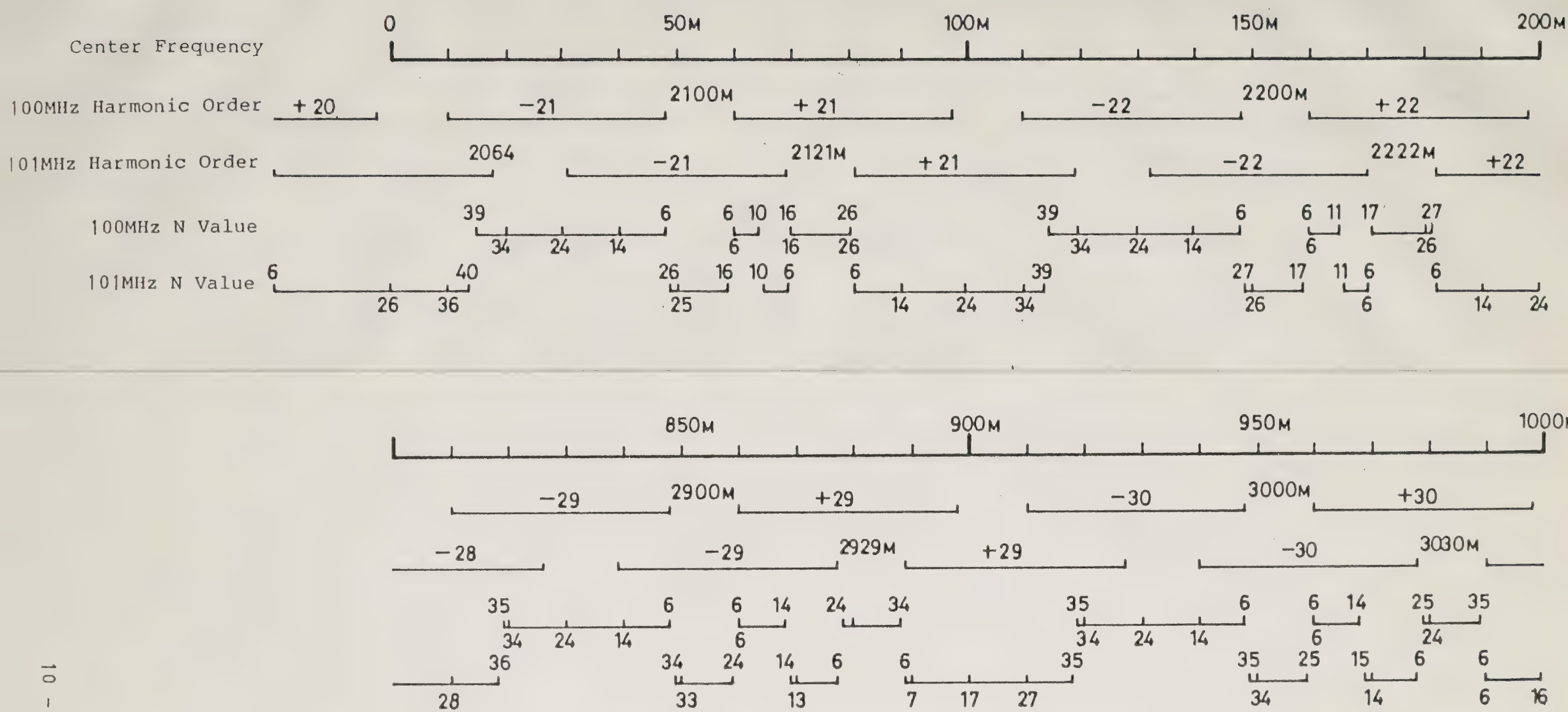


Fig. 10-12 TR4172 LOCK N value

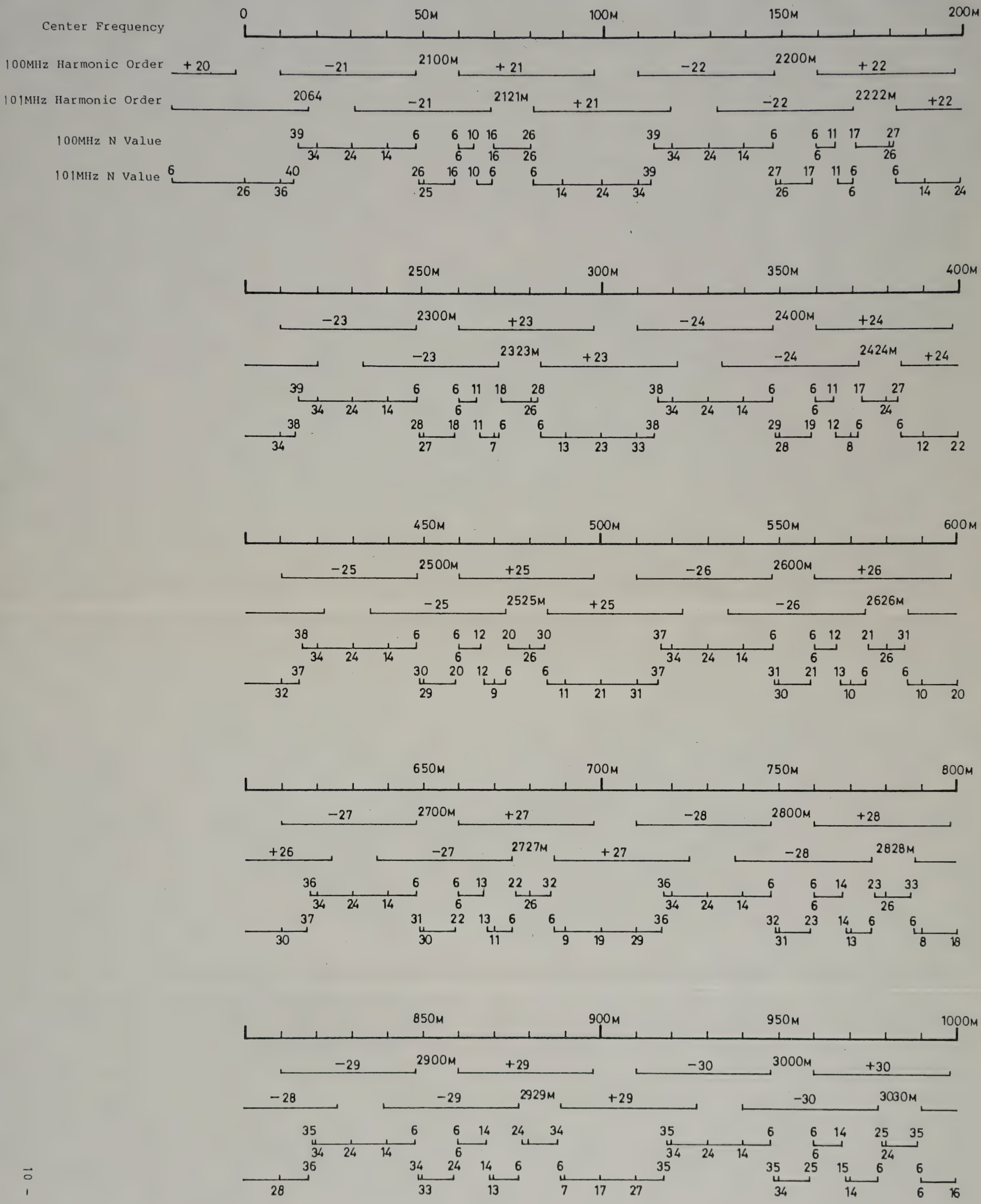


Fig. 10-12 TR4172 LOCK N value

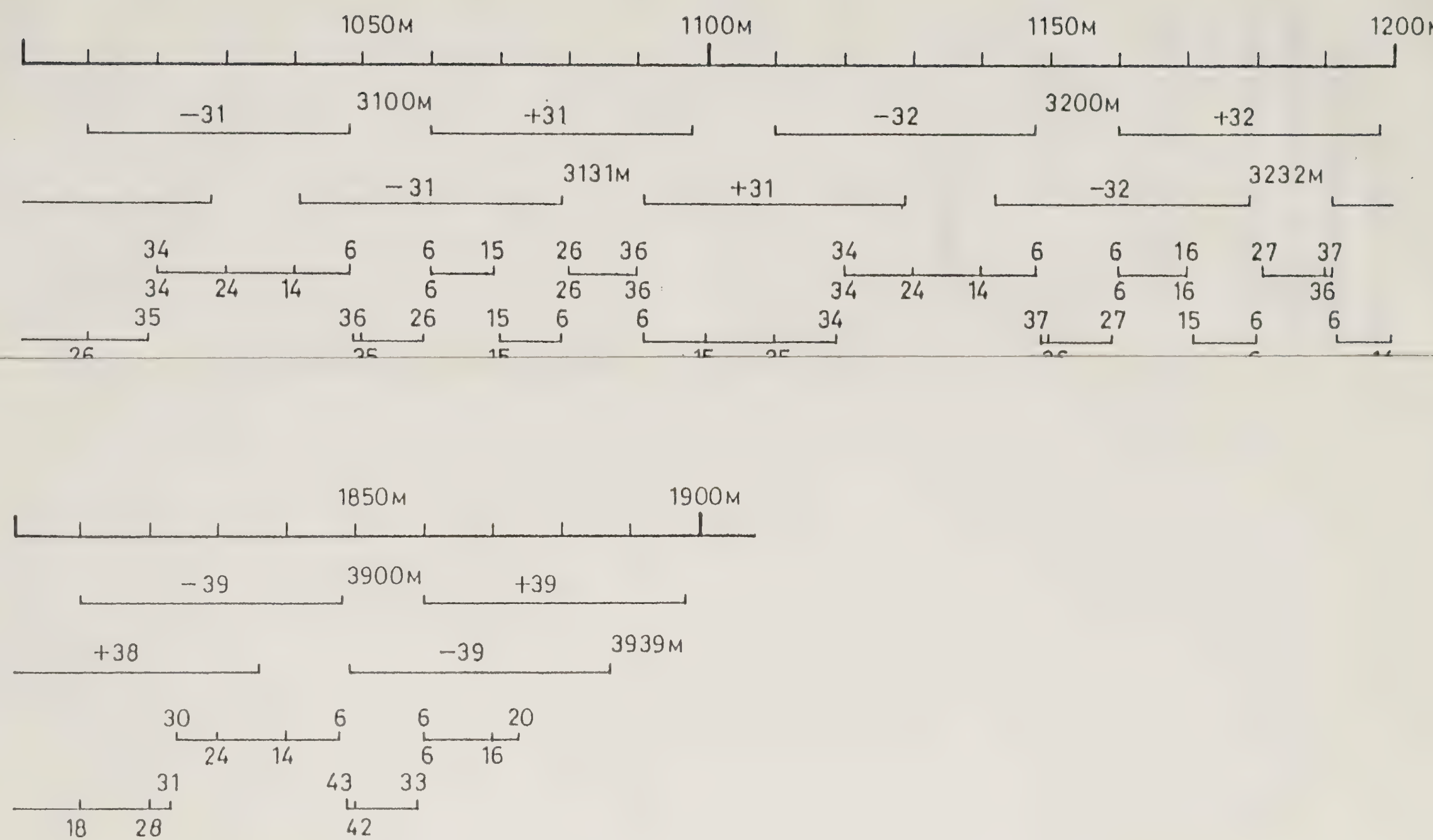


Fig. 10-12 TR4172 LOCK N value (Cont'd)

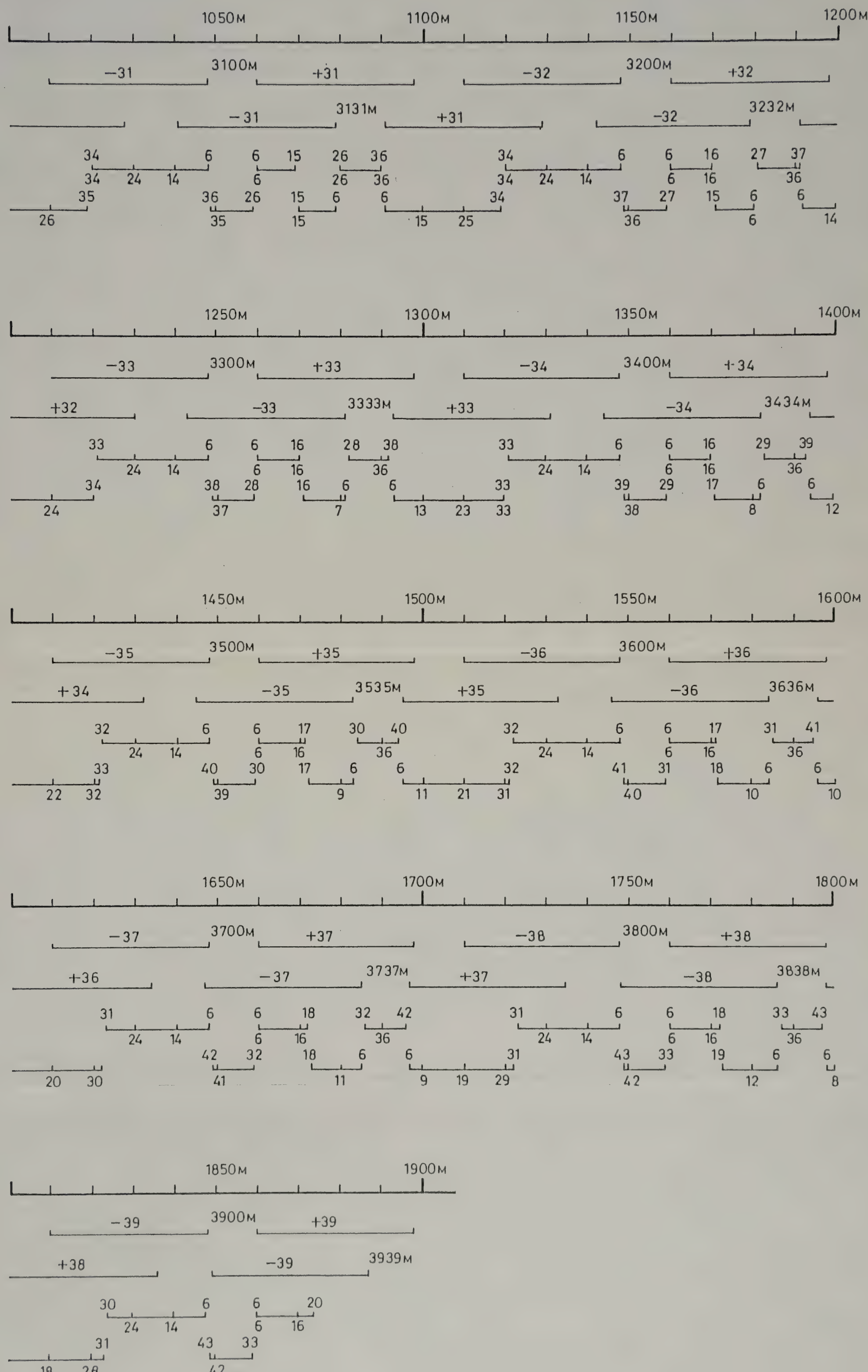


Fig. 10-12 TR4172 LOCK N value (Cont'd)

Comments on Figure 10-12

1) "M" in the figure means "MHz".

2) N value corresponding to center frequency, which is indicated by 10 MHz interval in this figure, is identified with the numerical characters marked at lower side of the 100 MHz N or 101 MHz N value scale.

   Therefore, 101 MHz N value is 26 at 0 MHz center frequency, and
   100 MHz N value is 6 at 260 MHz center frequency,
   for example.

3) N value counts up/down one by one as center frequency varies by 1 MHz.

   Therefore, N value at 26 MHz center frequency is determined;
   N = 34 - 6 = 28 , for example.
   (c.f.: N = 34 at 20 MHz center frequency, and
   N = 24 at 30 MHz center frequency.)

(3) 100/101 MHz PLL BLB-010120 (Circuit diagram No. 72)

As mentioned in paragraph (2), PLL networks are provided for the 100/101 MHz quartz-controlled oscillators using the 10 MHz time base frequency as a reference. The 10 MHz time base goes through a 1/2 divider and then x7 and x3 multiplier to generate a 105 MHz signal. This 105 MHz is mixed with the 100/101 MHz to generate 5 MHz/4 MHz IF signals. These IF signals are then divided by 5 and 4 respectively, and are compared, in terms of phase, with 1/10 (1 MHz) the time base frequency. The comparison result couples to an LPF to create control voltages. These control voltages are fed back to the 100/101 MHz oscillators to form PLL networks.

(4) 2 - 4 GHz PULSE GENERATOR BTB-010114 (Circuit diagram No. 66)

The 100/101 MHz oscillator outputs are applied to step recovery diodes to generate a comb signal of 2 to 4 GHz for the 100/101 MHz signals. The 2 to 4 GHz comb signal has a minimum level of -25 dBm.

(5) 1st LOCAL MIXER BLB-010116 (Circuit diagram No. 68)

Mixes the 2 to 4 GHz first local oscillator output from the isolation amplifier with the 100/101 MHz COM signal to generate a 6 to 44 MHz IF signal. This IF signal is taken out through a 45 MHz LPF.

(6) Digital phase detector BLB-010118 (Circuit diagram No. 70)

The IF signal output (6 to 44 MHz) of the first PLL mixer is converted to TTL level by an isolation amplifier and Schmitt trigger circuit. It is then divided by 2 and coupled to a dividing-by-N divider where it is frequency divided according to the dividing data furnished by the CPU. The signal is then assigned a + or - sign and coupled to the phase detector input. Since the input signal was divided by two before being coupled to the 1/N divider, the 1st local OSC output can be phase locked at 1MHz intervals if the reference signal is also divided by 2, that is, to 500 kHz.

The + or - sign determines to which input (of the two phase detector inputs) the reference signal is to be applied according to the information indicating whether the setup center frequency is higher or lower than the 100 and 101 MHz comb signal since the same IF signal may be output at two different center frequency settings. (See Figure 10-13.) The phase detector output is coupled to a PLL filter via an active LPF.

(7) PLL filter BLB-010119 (Circuit diagram No. 71)
The output of the digital phase detector is applied to the FM port of the YIG driver via this PLL filter to form a PLL loop.

10-3-7. Third Local Block (MEP-347)

Figure 10-14 shows the configuration of the third local block oscillator. This block contains a sweep oscillator which is activated at a frequency span below 500 kHz. It consists of five boards: 23 MHz VCO, 2 MHz VCO, 39 MHz mixer, 176 MHz mixer, and third local PLL. The third local block is controlled by the control signal from the 3rd Local Oscillator I/O.

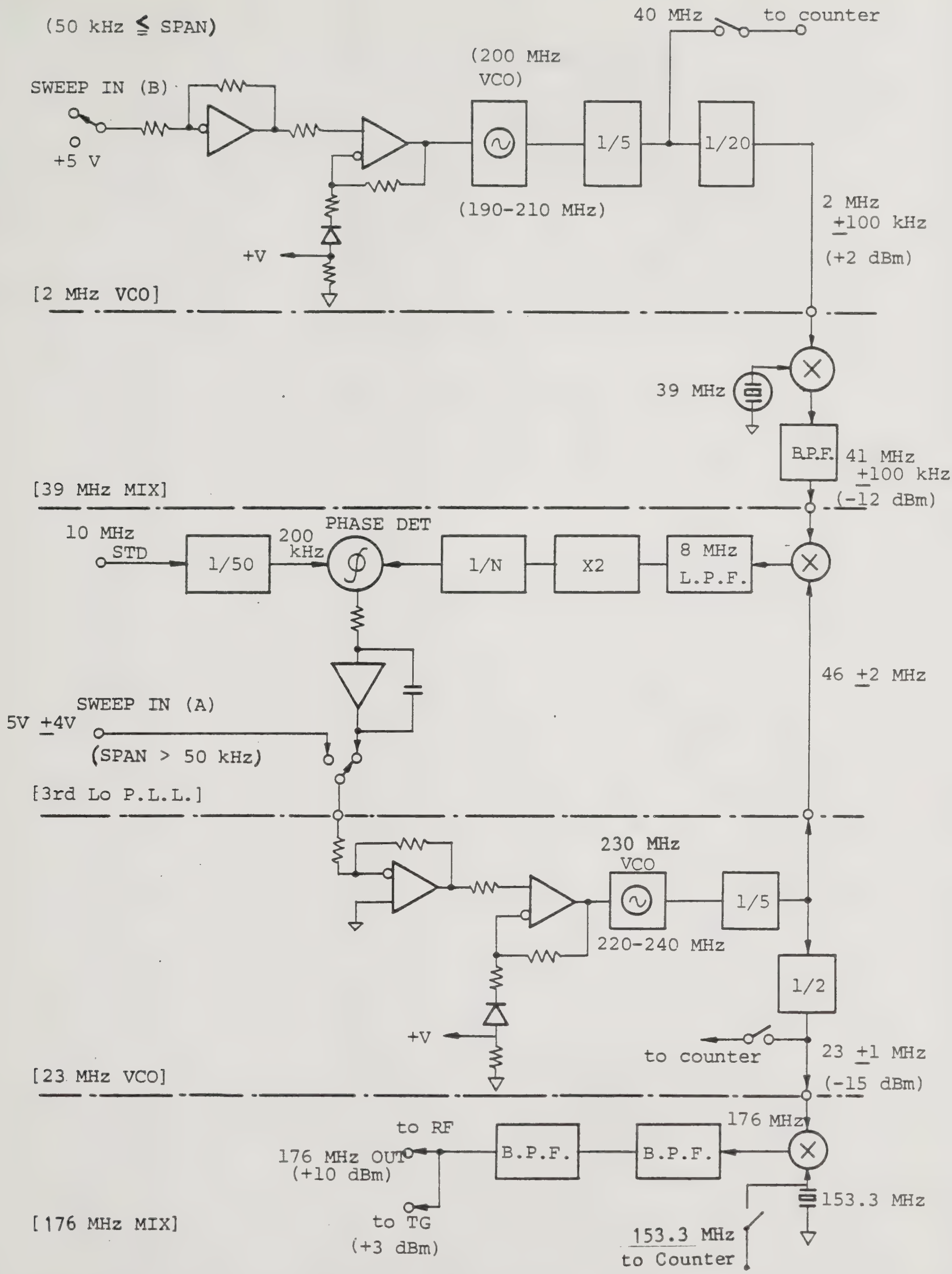


Fig. 10-13 Third local OSC block (MEP-347)

(1) 23 MHz VCO BLC-010101 (Circuit diagram No. 61)

A VCO output of 230 MHz is divided by 10 to create the output of this board and to improve phase noise characteristics. A cable with good vibration resistance and high Q is used for oscillator's inductance, while a varicap diode with good linearity is used for capacitance. The VCO control voltage is furnished from the third local I/O block (BGN-010221), and is coupled to the VCO diode via a lineanarizer. The VCO generates a frequency between 23 MHz $\pm$1 MHz by accepting a control voltage from 1 - 9 V.

The output of the VCO is divided by 5 and then 2 into 23 MHz, which is then coupled to the 150 MHz mixer (to be described later) via an LPF. Part of the VCO output is coupled to the counter block via a switch.

When frequency span of 50 kHz or below is selected, the VCO outputs a 46 MHz signal (after only divided by 5) which is used to form a PLL loop with the 2 MHz VCO (to be described in the following).

(2) 2 MHz VCO BLC-010102 (Circuit diagram No. 62)

The 2 MHz VCO has the same oscillator configuration as the 23 MHz VCO, with the exception that the oscillator of the former VCO oscillates 200 MHz. The oscillator output is divided by 5 and then 20 into 2 MHz, coupled to the 39 MHz mixer via an LPF, forming a PLL loop with the 23 MHz VCO. The output of the 1/5 divider also goes to the counter block. When a frequency span of 10 kHz, or below is selected, a capacitor is added to the drive voltage line to eliminate drive voltage noise.

The 2 MHz OSC oscillates a frequency between 2 MHz $\pm$100 kHz by accepting a control voltage from 1 to 9 V.

(3) 39 MHz mixer BLC-010100 (Circuit diagram No. 60)

Mixes the 39 MHz crystal oscillator output with the 2 MHz VCO output to create a 41 MHz signal, which is output via a BPF.

(4) Third local PLL BLC-010103 (Circuit diagram No. 63)

The third local PLL mixes the 46 MHz output of the 23 MHz VCO with the 41 MHz mixer output (described just above) to generate a 5 MHz IF signal. This IF signal is doubled into 10 MHz and then coupled to a 1/N divider. The output of the divider is phase-compared with a 200 kHz reference signal (obtained by dividing-by-50 the 10 MHz time base signal). The comparison result goes through an LPF, then couples to the control input of the 23 MHz VCO. If, at this time, the output of the 2 MHz VCO is swept over, the 23 MHz VCO also sweeps while maintaining phase lock. This sweep is effective at a frequency span of 50 kHz or below.

(5) 176 MHz Mixer BLC-010099 (Circuit diagram No. 59)

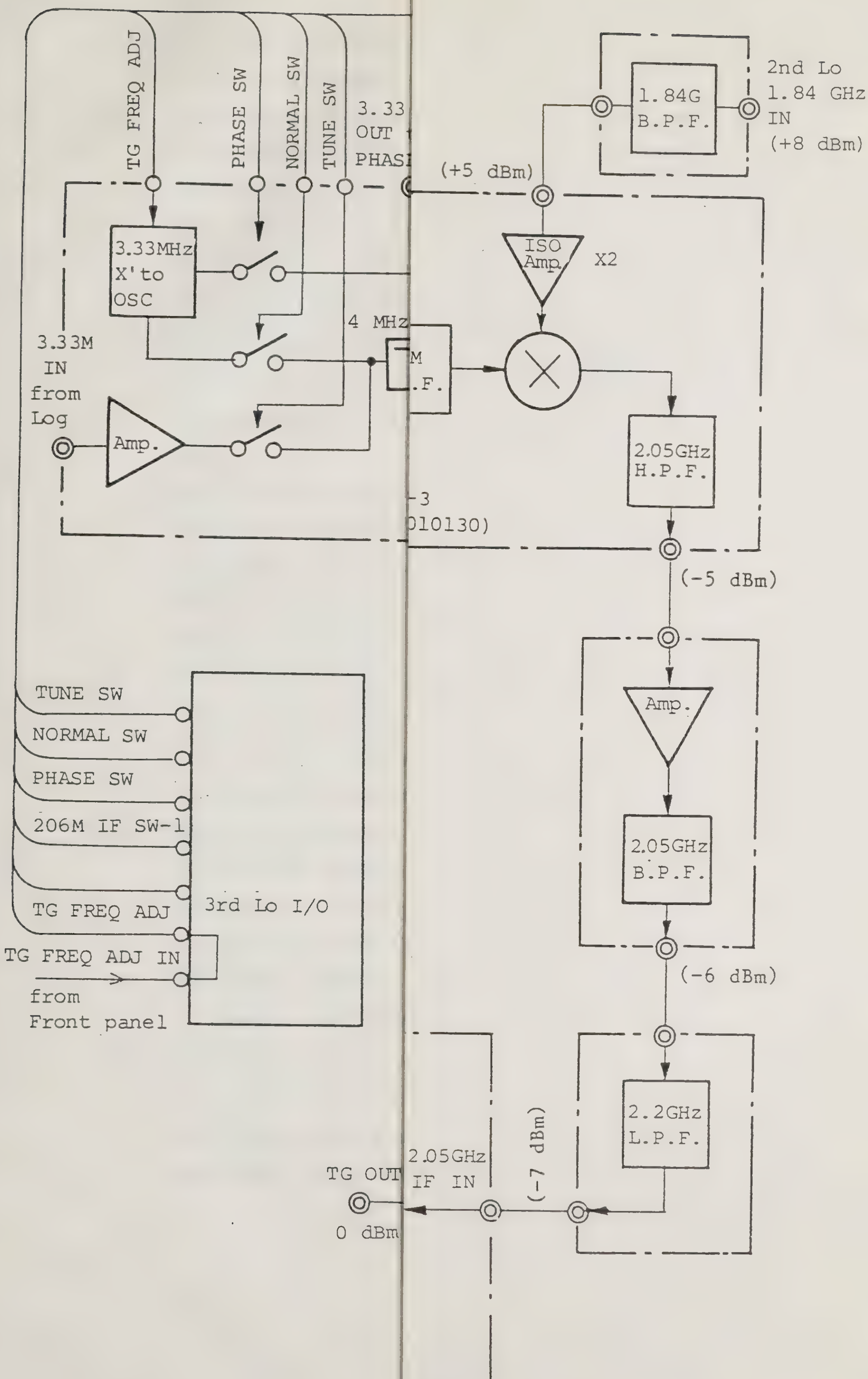
Mixes a quartz OSC output of 153.333 MHz with the 23 MHz VCO output to create the final 176 MHz ±1 MHz output of the third local OSC.

The output is coupled to the RF and TG blocks after amplified and passing through a BPF. The output of the 153.333 MHz OSC output is also applied to the counter block.

10-3-8. Tracking Generator Block (MEP-346) (Circuit diagram No. 54)

In the tracking generator, the outputs of the four internal local oscillators are beaded up in the direction reverse to the spectrum analyzer configuration and are swept over the set up frequency span on both sides of the center frequency. The output of the tracking generator covers a frequency range between 400 kHz and 1.8 GHz. To obtain a level deviation of less than ±0.7 dB p-p, it uses an ALC loop.

Figure 10-14 shows the configuration of the tracking generator block.


TG FREQ ADJ
PHASE SW
NORMAL SW
TUNE SW
3.33
OUT
PHASE
(+5 dBm)
1.84G
B.P.F.
2nd Lo
1.84 GHz
IN
(+8 dBm)
3.33MHz
X'to
OSC
ISO
Amp.
X2
3.33M
IN
from
Log
4 MHz
M
.F.
Amp.
2.05GHz
H.P.F.
-3
010130)
(-5 dBm)
Amp.
2.05GHz
B.P.F.
(-6 dBm)
TUNE SW
NORMAL SW
PHASE SW
206M IF SW-1
TG FREQ ADJ
3rd Lo I/O
TG FREQ ADJ IN
from
Front panel
2.2GHz
L.P.F.
(-7 dBm)
2.05GHz
IF IN
TG OUT
0 dBm

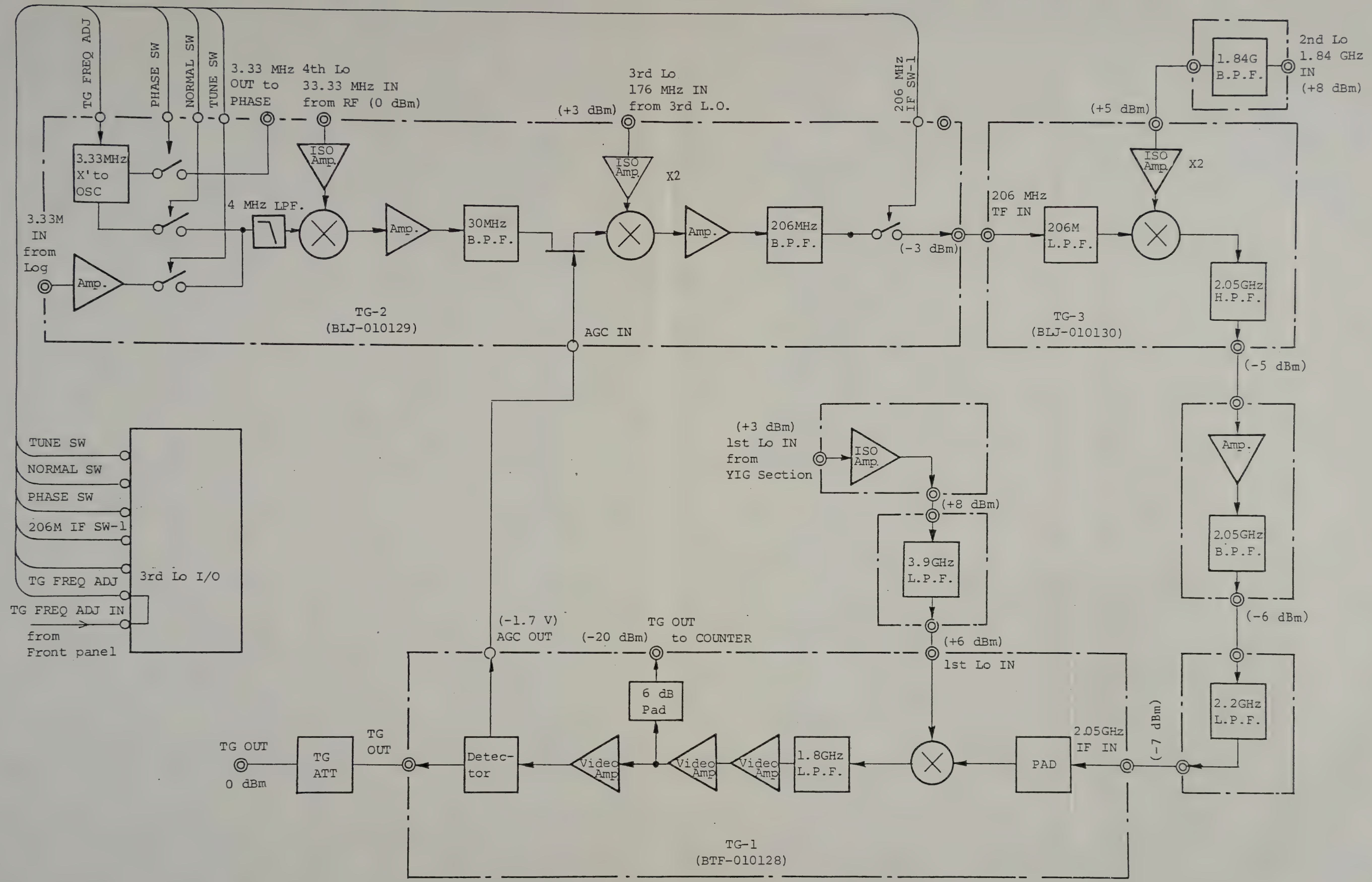


Fig. 10-14 Tracking generator block

(1) Tracking generator 2 BLJ-010129 (Circuit diagram No. 56)

The tracking generator contains a 3.333 MHz VCXO. When the RBW is narrowed down with the front T.G. FREQ. ADJ. control, the resulting tracking error is corrected by this block. For phase measurement, the 3.33 MHz output of this VCXO is used as one of the reference frequencies.

In the Normal mode, the output of the 3.33 MHz oscillator goes through an LPF and is then mixed with the fourth local OSC output coming from the RF block to create the TG 1st IF signal of 30 MHz. This IF signal goes through an amplifier and BPF, then couples to the following mixer via an FET attenuator for ALC.

The 30 MHz IF band-pass filter must have a pass bandwidth of approximately 2 MHz, since the operation level during tune amplifier operation is +15 dB higher than the noise level at an RBW of 1 MHz. The ALC control voltage is furnished from the Tracking Generator 1.

The 176 MHz output of the third local oscillator is coupled to the TG second mixer via an isolation amplifier and is converted into the 2nd IF signal of 206 MHz. This IF signal is coupled to the Tracking Generator 3 via a BPF.

(2) Tracking Generator 3 BTB-010130 (Circuit diagram No. 57)

The 206 MHz TG second IF signal furnished from Tracking Generator 2 is coupled to the TG third mixer (via an LPF), where it is mixed with the 2nd local oscillator output of 1.84 GHz furnished from the RF block via a BPF and isolation amplifier, to create the third IF signal of 2.046 GHz.

(3) 2.046 GHz isolation amplifier and BPF

The 2.046 GHz IF signal is output to Tracking Generator 1 via a 2.046 GHz tuned amplifier, BPF, and 2.2 GHz LPF. The tuned amplifier, BPF, and LPF are contained in a hybrid module.

(4) Tracking Generator 1 BTF-010128 (Circuit diagram No. 55)

The third TG IF signal of 2.046 GHz furnished from the above BPF is coupled to the TG final 4th mixer, where it is mixed with the first local OSC output of 2 - 4 GHz coming from the 3.9 GHz LPF block, to create the final TG output of 400 kHz to 1.8 GHz. This output is amplified by a three-stage video amplifier after passing through a 1.8 GHz LPF. The output to the counter is taken out from the middle of this video amplifier via a distributor.

The output level of the video amplifier is detected by a level detector and fed back to the FET attenuator in Tracking Generator 2 to form an ALC loop. The output of the tracking generator 1 is fixed at 0 dBm, and is coupled to the front panel connector via a TG attenuator.

10-3-9. 3.9 GHz LPF Block (MEP-351) (Circuit diagram No. 76)

The 2-4 GHz first local oscillator output for TG is furnished from a coupler in the YIG block to this 3.9 GHz LPF block. It then goes through a 2-4 GHz isolation amplifier and a 3.9 GHz LPF (which rejects second and higher harmonics) before output to the TG-1 block.

10-3-10. Counter Block (MEP-349) (Circuit diagram No. 73)

The counter block consists of a counter and counter switch. As shown in Figure 10-16. This block is used for center frequency setup or frequency measurement in the counter mode.

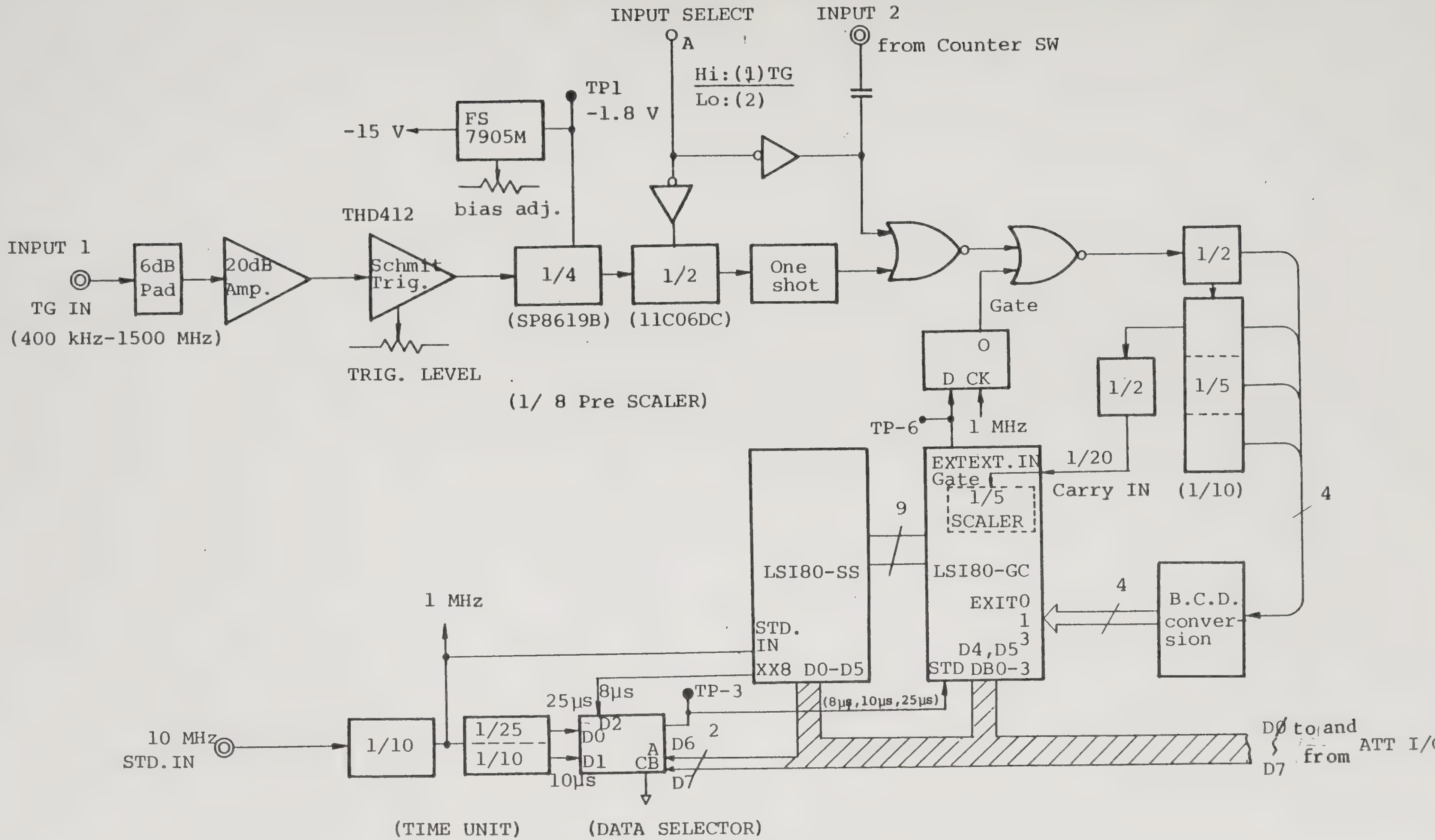


Fig. 10-15 Counter block configuration

(1) Counter (BLJ-010131) (Circuit diagram No. 74)

This counter covers a frequency range from 400 kHz to 1500 MHz. It has two inputs accepting the TG output and the output of the counter switch (Input-1 and Input-2). The TG output signal applied to Input-1 is amplified to a level adequate to drive the counter, goes through a Schmitt trigger circuit, divided by 4 and 2, and then coupled to the counter via a gate logic. Counter data and gate time setup information is furnished from the CPU via the ATT I/O block by the READ or WRITE signal. The signal for Input-2 is switched before the gate logic and treated in much the same way as the Input-1 signal.

(2) Counter switch (BLB-010505) (MEP-400) (Circuit diagram No. 75)

The counter switch selects one of the outputs of the third block 2 MHz VCO, 23 MHz VCO, first IF, RF block 204 MHz OSC, RF block 33.33 MHz, and third block 153.3 MHz, and couples it to the internal counter to read the selected output frequency.

10-3-11. Attenuator I/O (BGN-010220) (Circuit diagram No. 38)

This board takes out the following control data from the data bus to provide the corresponding control functions:

(1) Counter switch control

(2) Counter data send and receive

(3) TG attenuator control

(4) RF attenuator control

(5) DC-AC couple switching, Input 1 or 2 switching, and frequency response compensation

The frequency response compensation circuit creates a voltage to control the RF block gain according to the sweep and calibration signals to compensate for the frequency response slopes of the TR4172 attenuator, mixer, and so on. The addresses and data for each control signal are listed in Table 10-2.

Table 10-2 Attenuator I/O address and data

ADDRESS

A2	A1	A0	
0	0	0	Counter SW selection
0	0	1	Counter control
0	1	0	Counter data in/out
0	1	1	Tracking Generator Attenuator
1	0	0	RF input Attenuator
1	0	1	DC-cut, input select, RF level correction internal-standard ON/OFF, RF BW select.
1	1	0	Lock Interrupt Read

1) COUNTER SW SELECTION

DATA bit									
7	6	5	4	3	2	1	0		
0	0	0	0	0	0	0	1	T.G count	
0	0	0	0	0	0	1	0		
0	0	0	0	0	1	0	0	1st LOCAL IF	5 to 45 MHz
0	0	0	0	1	0	0	0	4th LOCAL	33.33 MHz
0	0	0	1	0	0	0	0	3rd LOCAL	153.33 MHz
0	0	1	0	0	0	0	0	3rd LOCAL 23 MHz VCO	about 23 MHz
0	1	0	0	0	0	0	0	3rd LOCAL 2 MHz VCO	about 2 MHz
1	0	0	0	0	0	0	0	2nd LOCAL	204.4 MHz

2) COUNTER CONTROL FUNCTION

DATA bit								
7	6	5	4	3	2	1	0	
					0			to counter latch out enable
				0				counter interrupt enable
			0/1					strobe
		0/1						select
0	0							counter time base 25 μ
0	1							counter time base 10 μ
1	0							counter time base 8 μ
1	1							

3) TG ATT. 4) RF ATT

DATA bit						RF ATT
5	4	3	2	1	0	
0	1	0	1	1	0	0 dB
0	1	1	0	1	0	-10 dB
1	0	0	1	1	0	-20 dB
1	0	1	0	1	0	-30 dB
1	0	0	1	0	1	-40 dB
1	0	1	0	0	1	-50 dB

5) DC CUT, INPUT SELECT, RF LEVEL CORRECTION, INTERNAL STD. ON/OFF RF BW SELECT.

DATA bit								
7	6	5	4	3	2	1	0	
							0/1	DC/AC
						0/1	0	INPUT1/INPUT2
			1	1	1			RF LEVEL CORRECTION
	0/1							RF BW SELECT (IF RBW 300 kHz to 10 Hz/1 MHz
1/0								INT. STD. ON/OFF

1: approximately +5 V
0: approximately 0 V

10-3-12. YIG OSCILLATOR I/O BGN-010219 (Circuit diagram No. 37)

This board takes out the following data from the data bus to provide the corresponding control functions:

(1) YIG OSC main tuning data

(2) YIG OSC FM tuning data

(3) YIG OSC sweep variable

(4) Sweep control (sweep attenuation, MAIN, FM, third sweep A, and third sweep B)

(5) YIG driver control

(6) First PLL block control

(7) Reference voltage source of ± 10 Vdc

The data given in item 1, 2, and 3 above are converted from digital codes into the corresponding analog voltages, which are then applied to the YIG driver.

The addresses, data, and output voltages for each control signal are listed in Table 10-3.

Table 10-3 YIG I/O address and data

ADDRESS

A2	A1	A0	CONTROL FUNCTION
0	0	0	TUNING MAIN
0	0	1	
0	1	0	TUNING FM
0	1	1	SPAN CONTROL (1) (Variable)
1	0	0	SPAN CONTROL (2) (1, 1/10, 1/100, ZERO)
1	0	1	1st LOCAL LOCK CONTROL
1	1	0	1st LOCAL LOCK (100 MHz/101 MHz) CONTROL
1	1	1	1st LOCAL LOCK 1/N

1) SPAN CONTROL (2)

DATA bit								FUNCTION	
7	6	5	4	3	2	1	0		
				1	1	1	0	SWEEP MAIN.	SPAN > 10 MHz
				1	1	0	1	SWEEP FM	10 MHz ≥ SPAN > 500kHz
				0	1	1	1	3rd LO SWEEP A	500 kHz ≥ SPAN > 50 kHz
				1	0	1	1	3rd LO SWEEP B	50 kHz ≥ SPAN
1	1	1	0					1/1 SPAN	
1	1	0	1					1/10 SPAN	
1	0	1	1					1/100 SPAN	
0	1	1	1					ZERO SPAN	

2) 1st LOCAL LOCK CONTROL

DATA bit								FUNCTION
7	6	5	4	3	2	1	0	
	0	1	1	1	0	1	1	INITIAL
					1	0	0	LOCK ON
					0	1	1	LOCK OFF
			1	0				YIG OSC FILTER ON SPAN ≤ 10 MHz
			0	0				YIG OSC FILTER ON SPAN ≤ 500 kHz

3) 1st LOCAL LOCK (100 MHz/101 MHz) CONTROL

DATA bit								FUNCTION
7	6	5	4	3	2	1	0	
							0/1	1st LOCAL PLL ± +/-
		1	0	1	0	1		100 MHz/101 MHz LOCK N=5
		0	1	1	1	0		N=4
	1							1st LOCAL IF COUNTER OUTPUT
		1	1					100 MHz/101 MHz OSC OFF

1: approximately +5 V
0: approximately 0 V

10-3-13. Third Local I/O Board ~~BGN-010221~~ (Circuit diagram No. 39)

This board takes out the following data from the data bus to provide the corresponding control functions for the third local block and TG block:

(1) Third Local Tune 1

(2) Third Local Tune 2

(3) Third Local Tune 3

(4) Third Local PLL 1/N Data

(5) Third Local Control (PLL, filter, counter switch)

(6) TG Control (Normal, Tune, Phase)

Tunes 1, 2, and 3 are used to set up the tuning voltages for the 23 MHz VCO and 2 MHz VCO by adding them to the sweep signal furnished from the YIG I/O board. The addresses, data, and output voltages of each control signal are listed in Table 10-4.

Table 10-4 Third Local I/O address and data

ADDRESS

A2	A1	A0	CONTROL FUNCTION
0	0	0	3rd LOCAL TUNING A
0	0	1	
0	1	0	3rd LOCAL TUNING B
0	1	1	3rd LOCAL TUNING C
1	0	0	3rd LOCAL LOCK I/N
1	0	1	3rd LOCAL PLL, 2 MHz VCO FILTER, COUNTER OUTPUT
1	1	0	TG CONTROL

1) 3rd LOCAL PLL, 2 MHz VCO FILTER, COUNTER OUTPUT

DATA bit					FUNCTION
4	3	2	1	0	
			1	1	3rd LOCAL PLL. LOCK ON SPAN $\leq$ 50 kHz
			0	1	2 MHz VCO FILTER SPAN $\leq$ 10 kHz
0	0	1			2 MHz VCO COUNTER OUT. CONTROL
0	1	0			23 MHz VCO COUNTER OUT. CONTROL
1	0	0			153.3 MHz COUNTER OUT. CONTROL

2) TG CONTROL

DATA bit					FUNCTION
4	3	2	1	0	
0	0	0	0	0	TG OFF
0	0	1	0	1	TG ON
0	0	1	1	0	TUNE MODE
1	0	1	0	1	PHASE 3.33 MHz OUTPUT ON

1: approximately +5 V

0: approximately 0 V

10-3-14. RF Section Power Supply (Mother, RF Power)

BLK-010226 BLF-010370

The RF section contains the following DC supply voltages:

+12 V, +15 V, -15 V, and +5 V

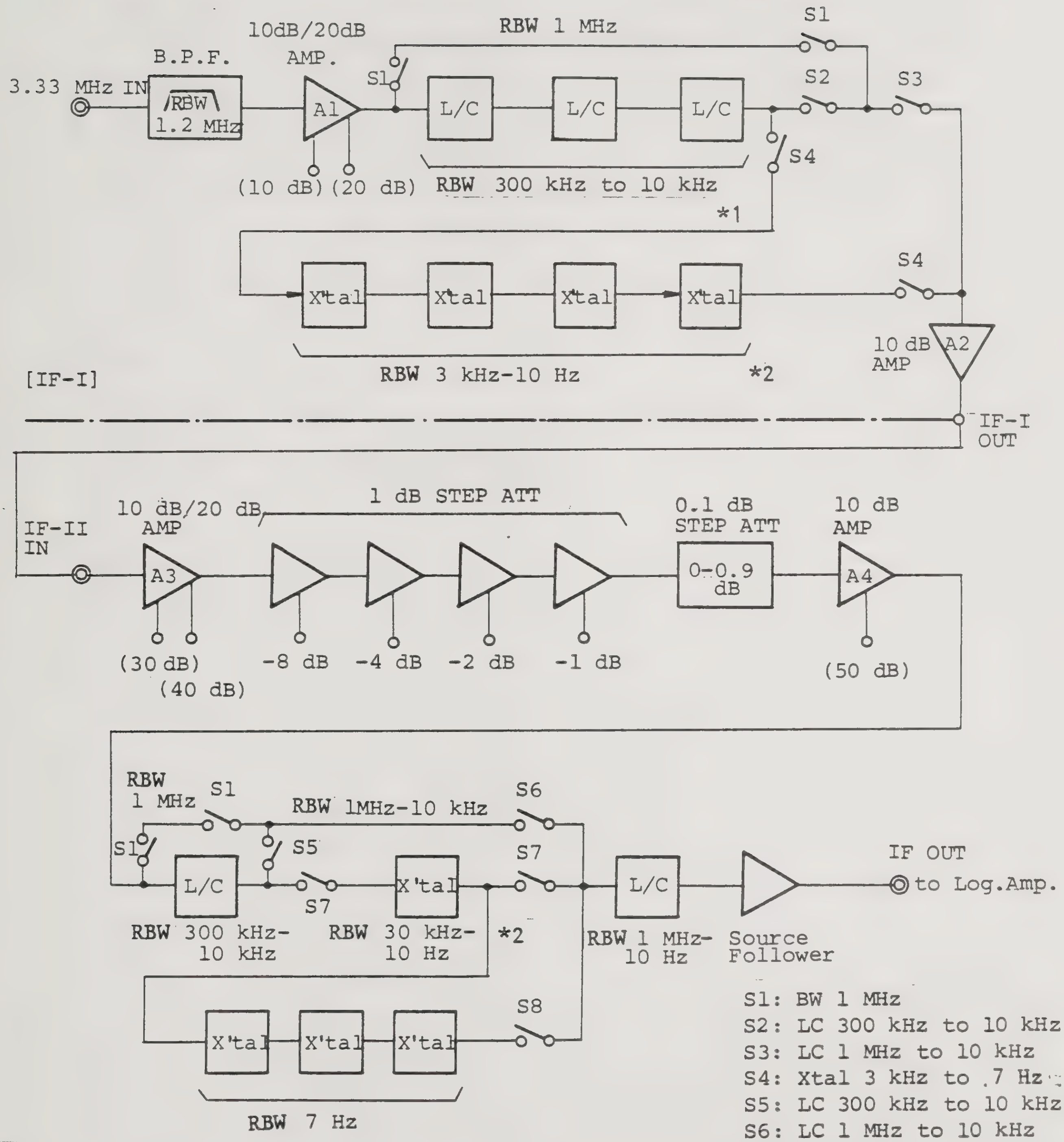
The +12 VDC is supplied to the thermostatic oven for the time base quartz-controlled oscillator and for memory back-up. It is left active as long as the power cable of the instrument is plugged into an AC power source. Note that unregulated voltages are also available. Each DC supply circuit has its own fuse and thermostat just before each voltage regulator.

10-4. DISPLAY SECTION FUNCTIONAL BLOCK DESCRIPTION

10-4-1. IF Block (MEP-338) BLP-010229 (Circuit diagram No. 25, 26)
BLP-010230 (Circuit diagram No. 27, 28, 29)

The IF block consists of an RBW to display the 3.33 MHz IF signal from the RF section, amplifier (with 10 dB gain) to control reference levels, and attenuators.

Figure 10-17 shows the configuration.



S1: BW 1 MHz
S2: LC 300 kHz to 10 kHz
S3: LC 1 MHz to 10 kHz
S4: Xtal 3 kHz to 7 Hz
S5: LC 300 kHz to 10 kHz
S6: LC 1 MHz to 10 kHz
S7: Xtal 3 kHz to 10 Hz
S8: Xtal 7 Hz

Note:

*1 When RBW $\leq$ 3 kHz, 30 kHz RBW is selected.

*2 When RBW is 7 Hz, 10 Hz RBW is selected.

Fig. 10-16 IF block configuration

The IF block is divided into IF-I and IF-II boards. The IF-I board holds three LC filters and four quartz filters. It performs RBW selection and signal path switching according to the control signal furnished from the IF-II board. The IF-II Board holds a 10 dB amplifier, attenuators with 1 and 0.1 dB steps, two LC filters, four quartz filters, and control circuit. Table 10-5 shows the control signals.

Table 10-5 IF control signals address and data

ADDRESS

A2	A1	A0	CONTROL FUNCTION
0	0	0	RESOLUTION BAND WIDTH
0	0	1	SWITCH CONTROL
0	1	0	STEP AMP 10 dB
0	1	1	1 dB ATT, 0.1 dB ATT.

1) RESOLUTION BAND WIDTH

DATA bit								RBW
7	6	5	4	3	2	1	0	
			1	0	0	0	0	1 MHz
			1	0	0	1	0	300 kHz
			1	0	1	0	0	100 kHz
			1	0	1	1	0	120 kHz
			1	1	0	0	0	30 kHz
			1	1	1	1	0	10 kHz
1	1	1	0	1	1	1	0	9 kHz
1	1	1	0	1	0	0	0	3 kHz
0	0	0	0	1	0	0	0	1 kHz
0	0	1	0	1	0	0	0	300 Hz
0	1	0	0	1	0	0	0	200 Hz
0	1	1	0	1	0	0	0	100 Hz
1	0	0	0	1	0	0	0	30 Hz
1	0	1	0	1	0	0	0	10 Hz
1	1	0	0	1	0	0	0	7 Hz

2) SWITCH CONTROL

DATA bit								RBW
7	6	5	4	3	2	1	0	
1	0	1	1	0	1	0	1	RBW 1 MHz
1	0	1	1	0	1	1	0	RBW 300 kHz to 10 kHz
0	1	0	0	0	1	1	0	RBW 9 kHz (OPTION 01)
0	1	0	0	1	0	0	0	RBW 3 kHz to 10 Hz
1	1	0	0	1	0	0	0	RBW 7Hz

3) STEP AMP 10 dB

DATA bit								STEP AMP
7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	1	10 dB
0	0	0	0	0	0	1	0	20 dB
0	0	0	0	0	1	1	0	30 dB
0	0	0	0	1	0	1	0	40 dB
0	0	0	1	1	0	1	0	50 dB

4) 1 dB ATT 0.1 dB ATT

DATA bit				0.1 dB ATT
7	6	5	4	
0	0	0	1	0.1 dB ATT
0	0	1	0	0.2 dB ATT
0	0	1	1	0.3 dB ATT
0	1	0	0	0.4 dB ATT
0	1	0	1	0.5 dB ATT
0	1	1	0	0.6 dB ATT
0	1	1	1	0.7 dB ATT
1	0	0	0	0.8 dB ATT
1	0	0	1	0.9 dB ATT

DATA bit				1 dB ATT
3	2	1	0	
0	0	0	1	1 dB ATT
0	0	1	0	2 dB ATT
0	0	1	1	3 dB ATT
0	1	0	0	4 dB ATT
0	1	0	1	5 dB ATT
0	1	1	0	6 dB ATT
0	1	1	1	7 dB ATT
1	0	0	0	8 dB ATT
1	0	0	1	9 dB ATT
1	0	1	0	10 dB ATT
1	0	1	1	11 dB ATT
1	1	0	0	12 dB ATT
1	1	0	1	13 dB ATT
1	1	1	0	14 dB ATT
1	1	1	1	15 dB ATT

10-4-2. Logarithmic Amplifier Block (MEP-337) BLP-010231

(Circuit diagram No. 30)

Figure 10-18 shows the Log Amplifier block configuration.

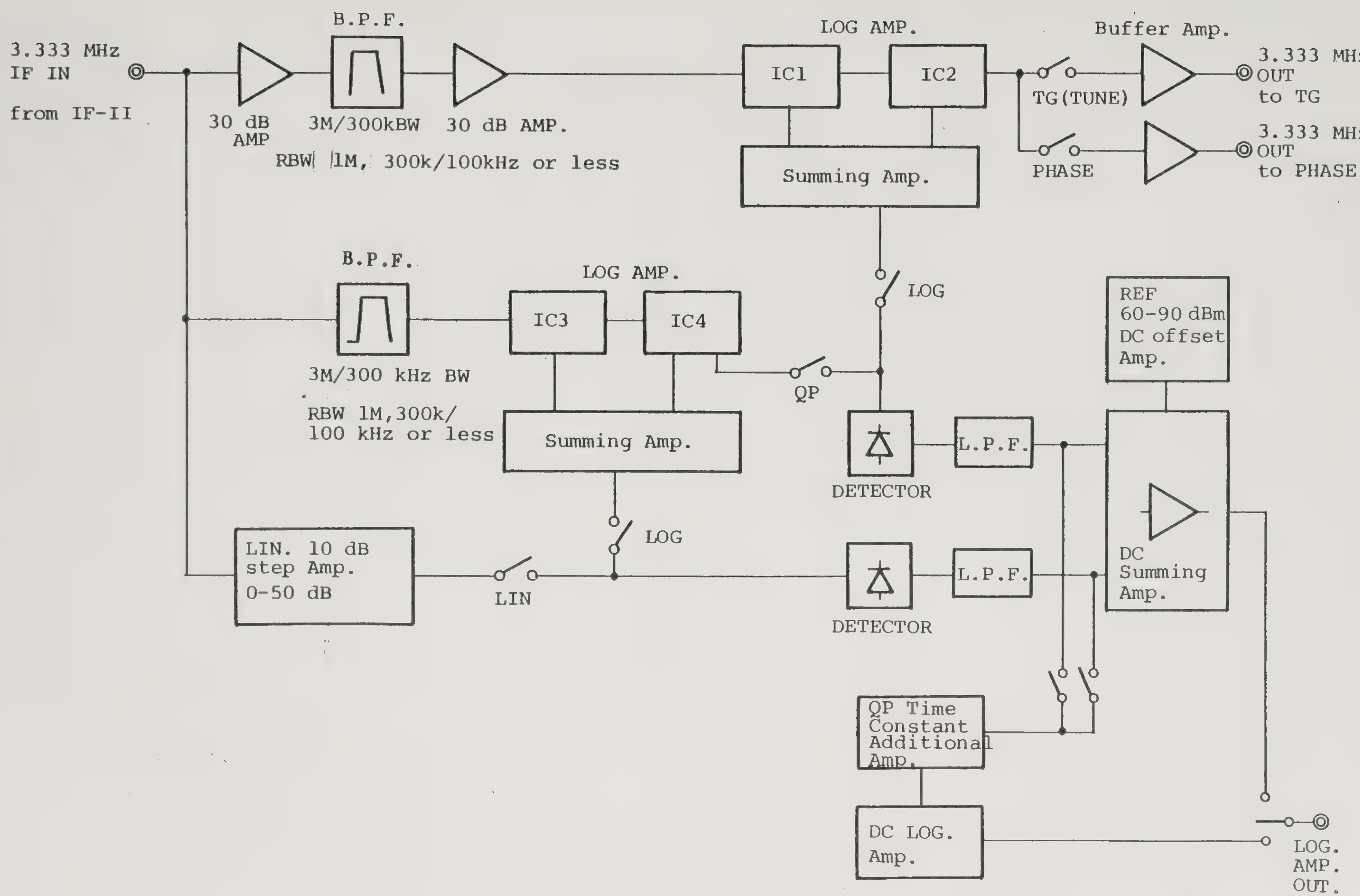


Fig. 10-17 Log. Amp. configuration

The Log Amplifier compresses the output of the IF block into logarithmic scale, and converts it into DC voltage.

In the Log mode, the 3.33 MHz IF signal is coupled to IC3 and IC4, where it is amplified by 60 dB. The output of these ICs are coupled to IC1 and IC2, where it is compressed into logarithmic scale. IC1 and IC2 handle signal levels between -60 and -100 dB, while IC3 and IC4 handle those between 0 and -50 dB.

The output of these IC1 and IC2 are added by IC5 and IC6 and converted to be dc voltage and output.

In the Linear mode, the 3.33 MHz IF signal is coupled to a linear amplifier with 10 dB step gain, where it is amplified, and then detected before output.

In the QP mode, the output voltage obtained in the Log mode is added to that obtained in the Linear mode. The resulting signal is output after adding the charging/discharging time constants specified in the C.I.S.P.L. standard.

10-4-3. Phase Block (MEP-339) BLP-010205 (Circuit diagram No. 31, 32)

Figure 10-18 shows the phase block configuration.

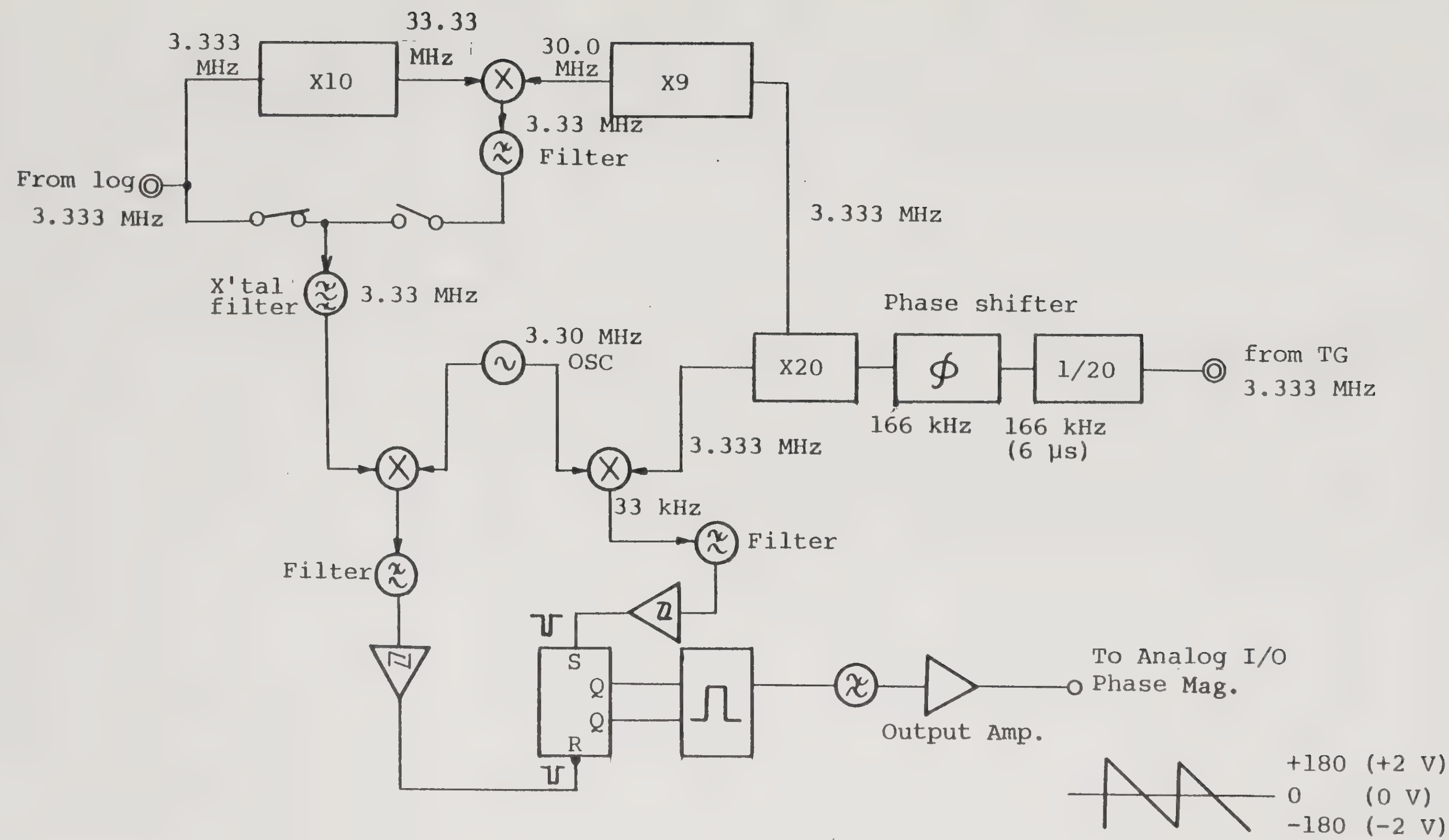


Fig. 10-18 Phase block configuration

On the TR4172, phase information is displayed on its video monitor be exercising phase comparison between the TG time base signal of 3.333 MHz and the final IF signal (i.e. the output of the Log Amp.) for the input signal.
The time base signal of 3.333 MHz furnished from the tracking generator is first divided by 20 into 166 kHz. It then goes to a phase shifter circuit for electrical length compensation, where the signal phase is made variable, before being multiplied again by 20 into 3.333 MHz. This 3.333 MHz time base signal and another 3.333 MHz IF signal from the Log Amplifier are both down-converted with a 3.30 MHz local frequency into 33 kHz, which is coupled to a phase detector. The output of the phase detector is output to the analog I/O board (to be described later) via an LPF.
To detect and display small phase differences, a 33.33 MHz (which is obtained by multiplying-by-10 the 3.333 MHz IF signal from the Log Amp.) and the 3.333 MHz time base signal (which is obtained by multiplying-by-9 the 30.000 MHz IF signal from the TG) are mixed together into 3.33 MHz when the phase range is 4 deg/div. or below. This 3.33 MHz is phase-compared with the 3.33 MHz time base signal from the tracking generator. As a result, a phase difference ten times larger can be obtained, which allows display of small phase differences.

10-4-4. CRT Driver (BGK-010184) (Circuit diagram No. 10)

The CRT driver accepts the X and Y signals from the analog I/O board to drive the CRT display. It contains a CRT bias voltage, blanking, dynamic focus, and other circuits.
Along with the blanking function, the blanking circuit also provides a function to intensify only signal response traces on the display by using the ΔY signal supplied from the analog I/O board, so that the traces are clearly visible in contrast with other information display (such as messages, labels, or scale).
In order to compensate for the focus characteristics of the CRT, the dynamic focus circuit uses a ramp voltage to control the focus voltage to obtain even focus over the entire screen.

10-4-5. High Voltage (BLP-010204) (Circuit diagram No. 9)

This circuit generates high voltage for the CRT. Figure 10-20 shows the circuit configuration. Table 10-6 shows typical CRT bias voltages.

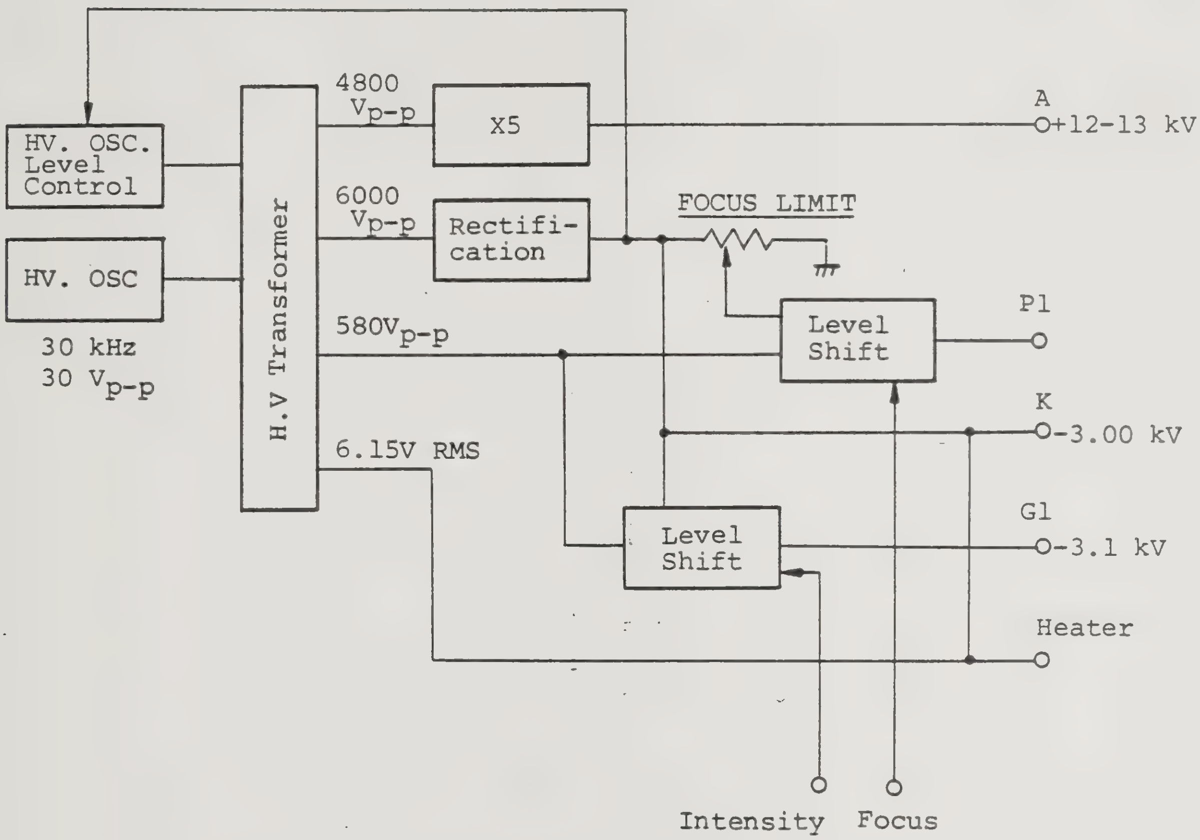
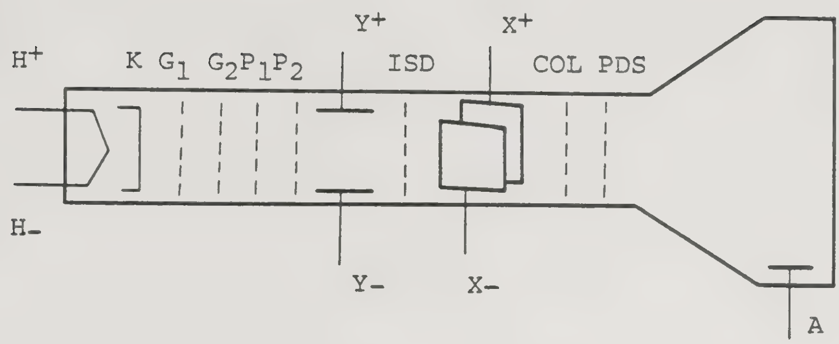


Fig. 10-19 High voltage circuit configuration

Table 10-6 CRT bias voltage



A	12 to 13 kV
k	-3 kV
G_1	-3 to -3.1 kV
G_2	68 to 88 V
P_1	-2.4 kV
P_2	0 to 135 V
ISD	0 to 135 V
COL	0 to 135 V
PDS	0 to 135 V
H	6.15 V RMS

A sine wave of approximately 30 kHz in frequency and 30 Vp-p in amplitude is generated by a blocking oscillator. The output of this oscillator is stepped up by a high voltage transformer into approximately -3 kV, which is used as a cathode voltage for the CRT. Part of this voltage is fed back to the oscillator to stabilize the oscillation.

An anode voltage is boosted by the booster block into +12 to +13 kV. The intensity and focus voltages furnished from the CRT driver control the potentials at G1 and P1 electrodes of the CRT respectively.

10-4-6. Ramp Generator (BGP-010185) (Circuit diagram No. 11)

The ramp generator consists of a saw-tooth generator for X-axis sweep and a sweep trigger circuit. Sweep time can be set up between 1 μs and 1000 sec either by controlling the input current to the integrating circuit (by means of a D-A converter) or switching the integrating capacitors and input resistors. The output voltage to the display section is from -5 V to +5 V, while that to the RF section is from +5 V to -5 V.

10-4-7. Analog I/O (BGP-010186) (Circuit diagram No. 12)

The analog I/O board contains a DC amplifier section which performs A-D conversion on the input signal from the LOG and Phase blocks, and line generator, character display, and scale display sections which, in combination, processe the X and Y signals furnished from the D/A board and outputs to the CRT driver.

(1) Log Mag Amp section
Consists of a DC amplifier for switching between 10, 5, 2, and 1 dB.

(2) Phase, GD Mag Amp section
Consists of a DC amplifier for switching between 80, 40, 20, ... 0.2 deg/div.

(3) Video Filter section
1 MHz to 1 Hz LPF and 1-3 step switching circuit.
The outputs of these three circuits are output to the A/D board, where they are converted into digital codes and processed by the CPU.

(4) Line generator section
This section contains an integration circuit which smoothes the step-like output of the D/A converter.

(5) Character display section
This section adds character voltage to the X and Y voltages from the D/A board to display character information, such as labels or readouts, on the display.

(6) Graticule display section

This section displays the graticule of 10 x 10 divisions on the screen.

See paragraph 10-4-14 for basic display operations.

10-4-8. A-D Converter Section (BGP-010187) (Circuit diagram No. 13)

(1) A-D converter

A-D converter section contains a peak detector (for the Y signal furnished from the analog I/O board) and A-D converter. It converts the X signal (furnished from the ramp generator) into digital code and outputs it on the data bus.

(2) Peak detector circuit

There are four detection modes: Normal, Positive, Negative, and Sample modes. The Normal mode detects whether the input voltage is increasing or decreasing. If the voltage is increasing, it automatically selects the positive detector; if the voltage is decreasing, it automatically selects the negative detector. In either case, the detector holds the peak level.

Figure 10-20 shows the circuit operation timing.

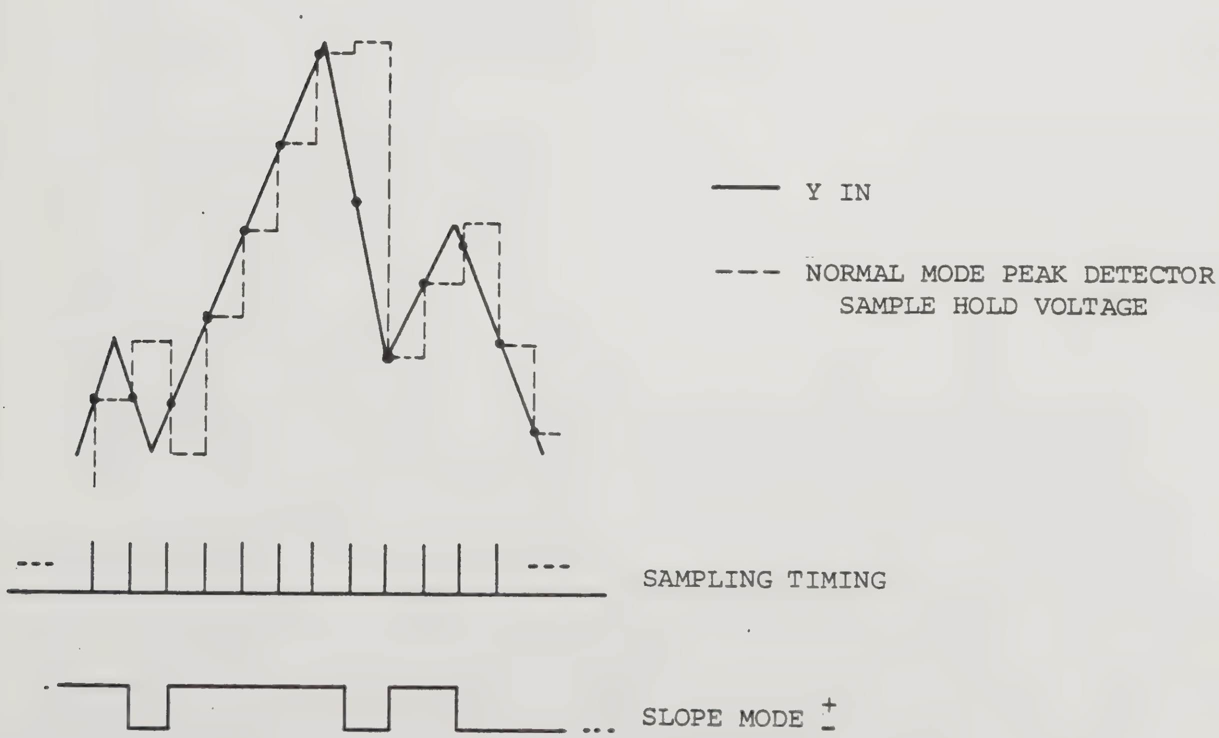


Fig. 10-20 Peak detector normal mode timing chart

(3) A/D converter circuit

The voltage held by the detector circuit is analog - to digital converted by a successive approximation A-D converter to generate a Y signal. The ramp voltage is analog - to digital converted by a follow up approximation A-D converter to generate an X signal.

10-4-9. D/A Converter (BGP-010188) (Circuit diagram No. 14)

The D/A converter reads data in the spectrum, character, line, and some other display modes (to be described later) by a control signal furnished from the display controller, converts it into the X and Y signals, and outputs them to the analog I/O board.

10-4-10. Display Control (BGP-010189) (Circuit diagram No. 15)

The display control provides various display control signals and timing to display data in different display modes which will be described later.

10-4-11. I/O and GP-IB (BGP-010190) (Circuit diagram No. 16, 17)

The I/O and GP-IB section consists of the following five circuits:

(1) CS signal generator for each I/O in the display and RF sections. The CS signal is used to activate the function selected from the keyboard.
(2) Timing controller for control signals
(3) Interrupt input circuit
(4) Address bus control for D/A board memory
(5) GP-IB interface (TMS9914)

10-4-12. CPU (BGP-010191) (Circuit diagram No. 19, 20)

The CPU section consists of a Z80 processor, ROM (8 kbytes), RAMs (64 kbytes dynamic RAM, which holds data after A/D conversion), clock generator, reset circuit, and others.

10-4-13. Memory Key Control (BGP-010192) (Circuit diagram No. 21, 22)

This section consists of 64 kbyte-ROMs, 8 kbyte-RAM and key control circuit.
The 8 kbyte-RAM is used for data save and recall operations. It is backed up by an internal battery so its contents are left intact even when the instrument is switched off. The battery can hold the memory contents for approximately two weeks.
The key control provides all control over all the keys on the display and RF sections, LED indicators, and data read operations using the DATA knob.

10-4-14. Display Operation

The CRT display on the TR4172 uses the random scan system, in which information display is made by specifying the X and Y coordinate values on the screen. The display modes include the following five modes:

(1) Character display
(2) Line display
(3) Spectrum display
(4) Graphic display
(5) Analog display

Each of these modes (jobs) is illustrated in Figure 10-22.

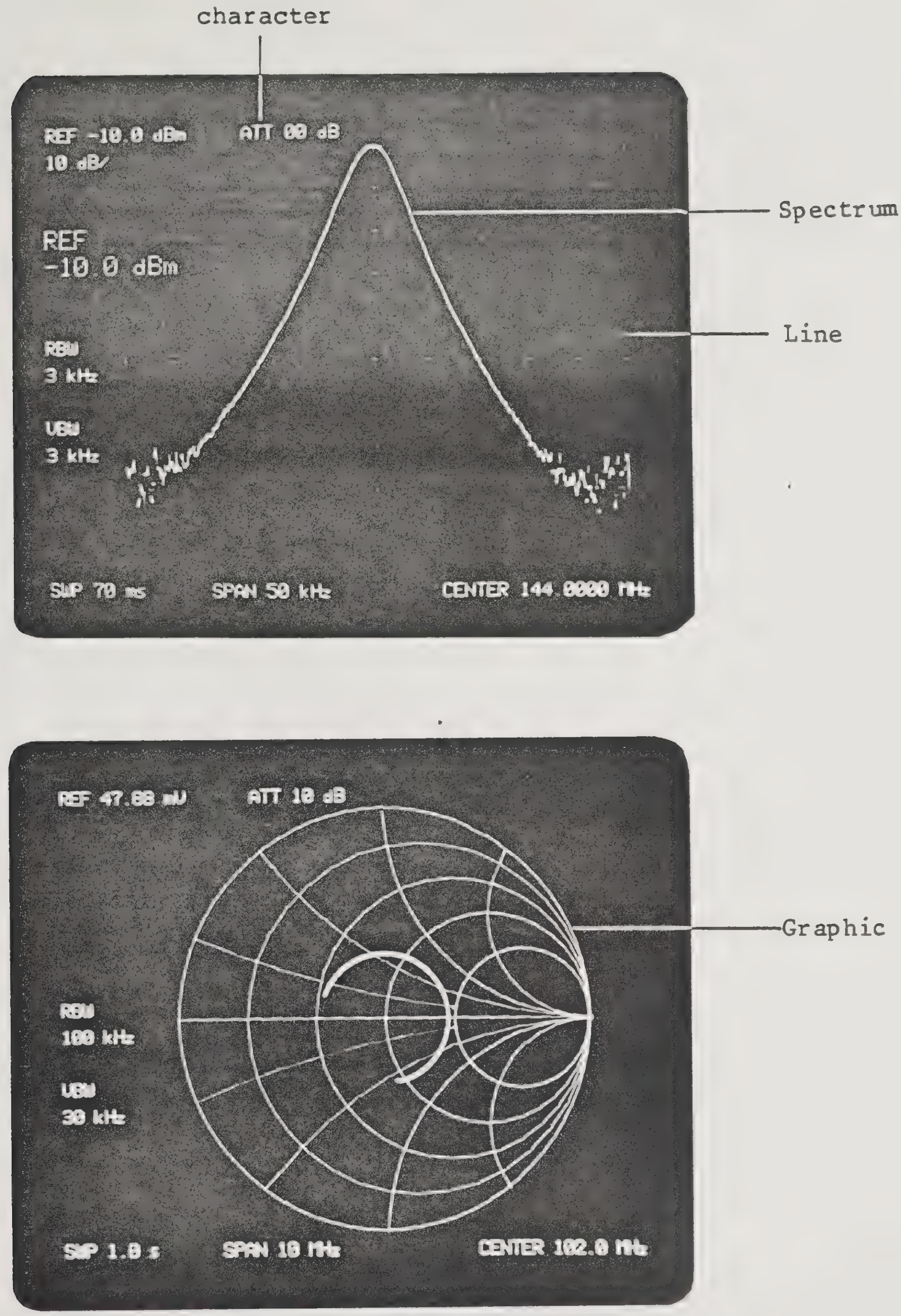


Fig. 10-21 Display modes

Display operation starts with fetching the specified job contents from the job memory in the display control. Control signals and timings are determined according to this job memory contents, and are output to the analog I/O board. Figure 10-22 shows a flowchart for display operation.

Display flowchart

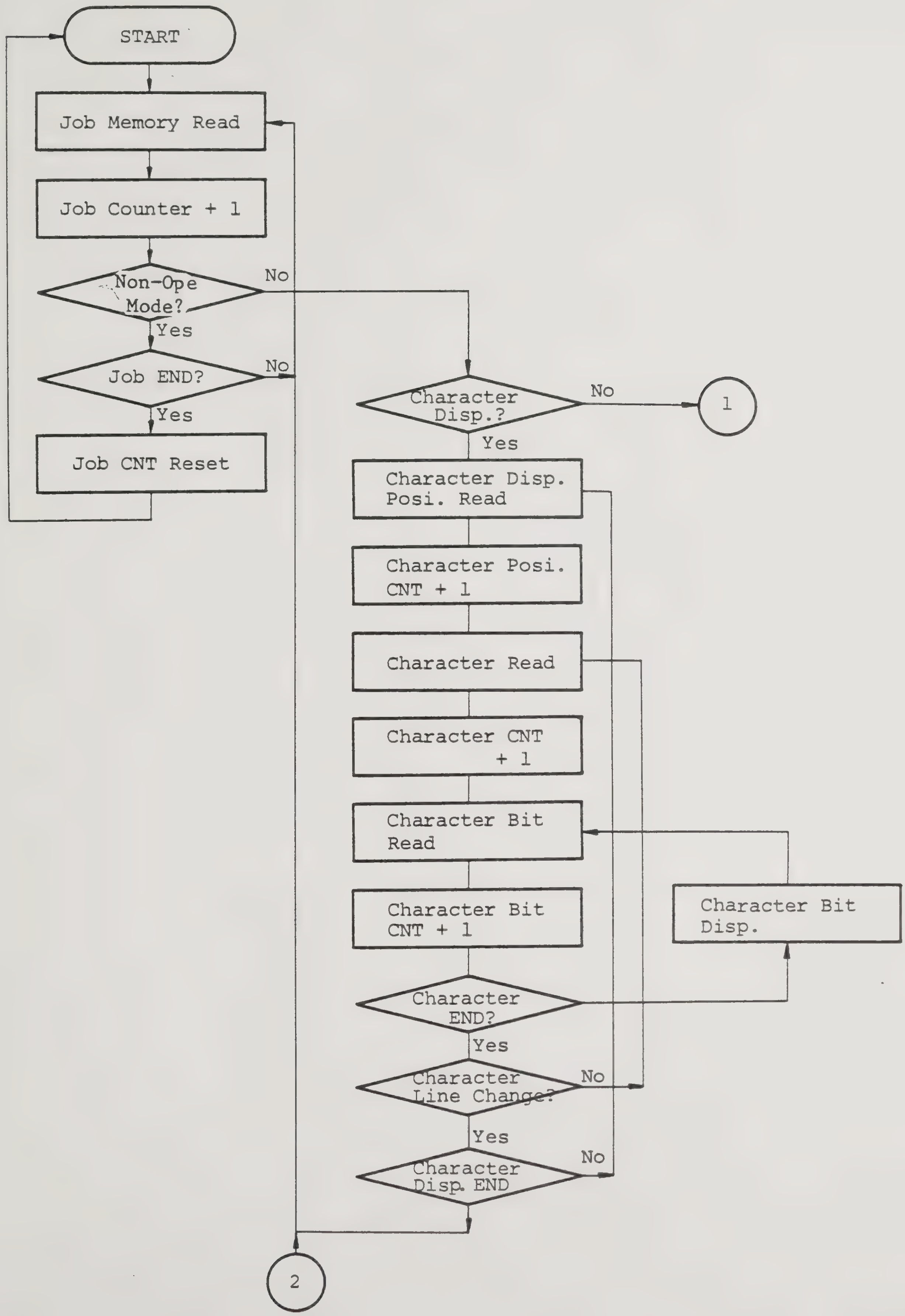


Fig. 10-22 Display operation flowchart

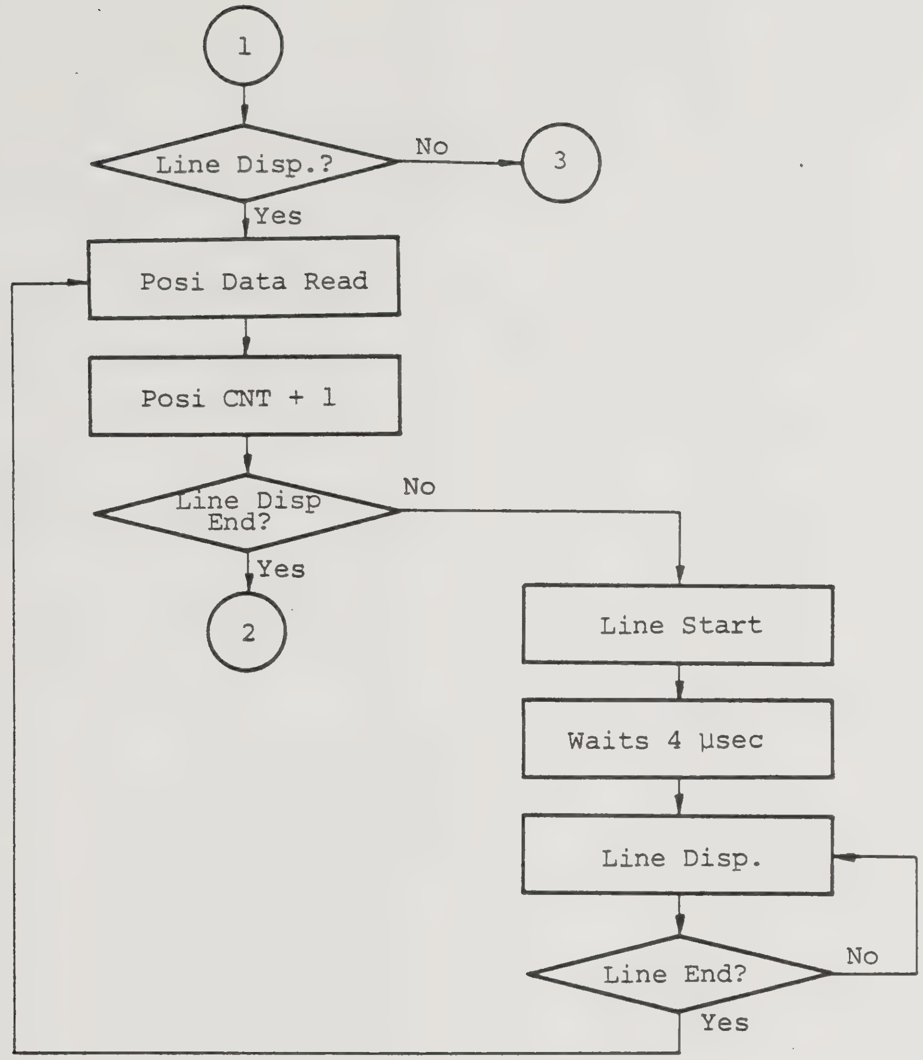


Fig. 10-22 Display operation flowchart (Cont'd)

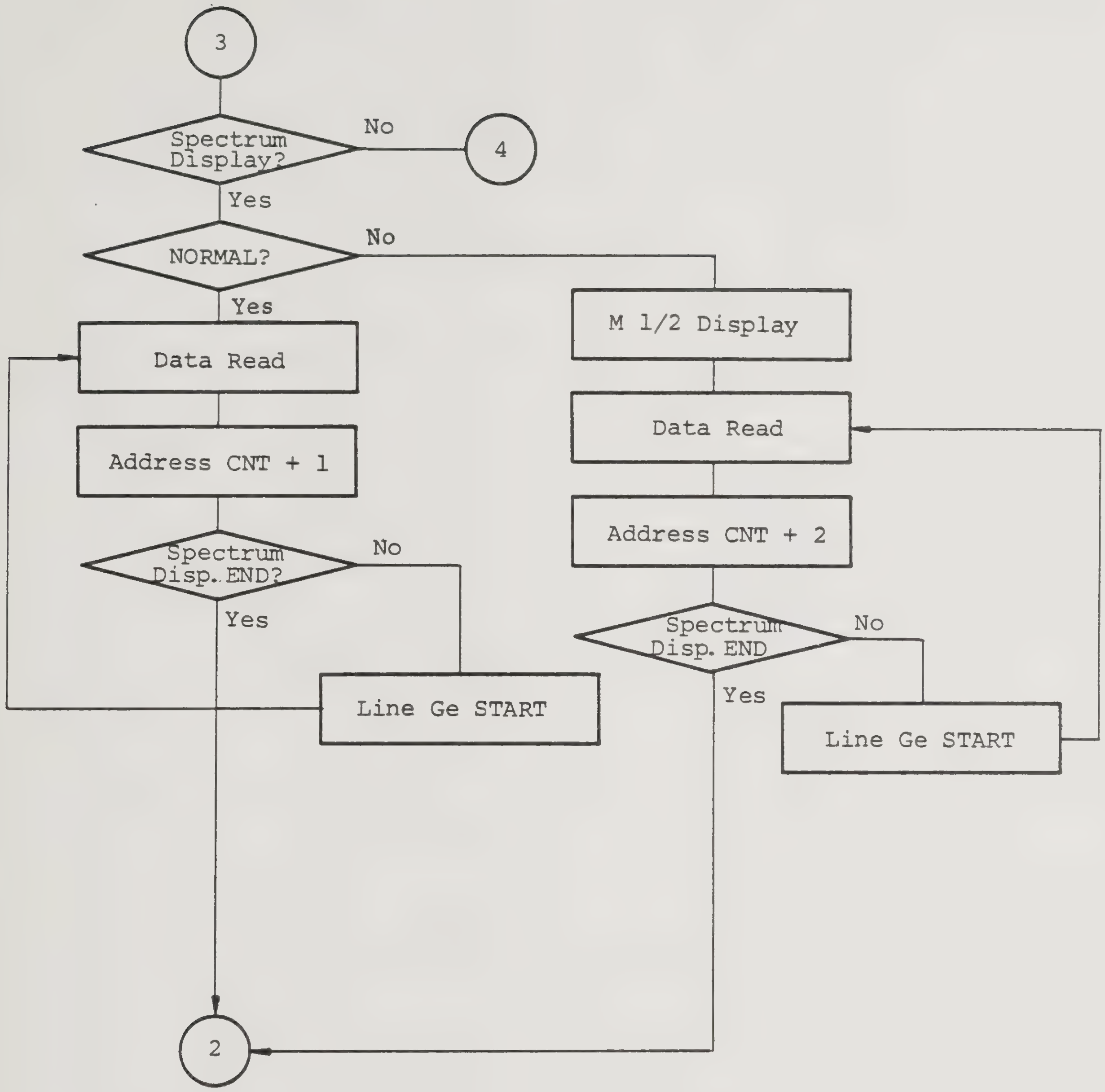


Fig. 10-22 Display operation flowchart (Cont'd)

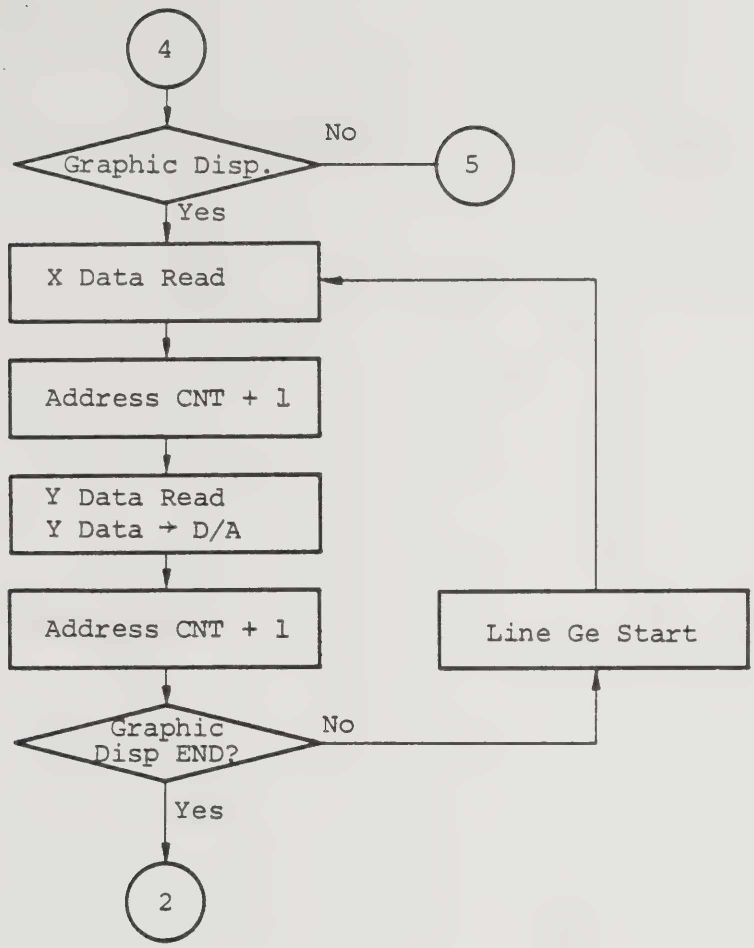


Fig. 10-22 Display operation flowchart (Cont'd)

(1) Character display

Figure 10-23 shows a block diagram relating to character display operation. Character information includes all labels, setup information, and readouts on the display operation.

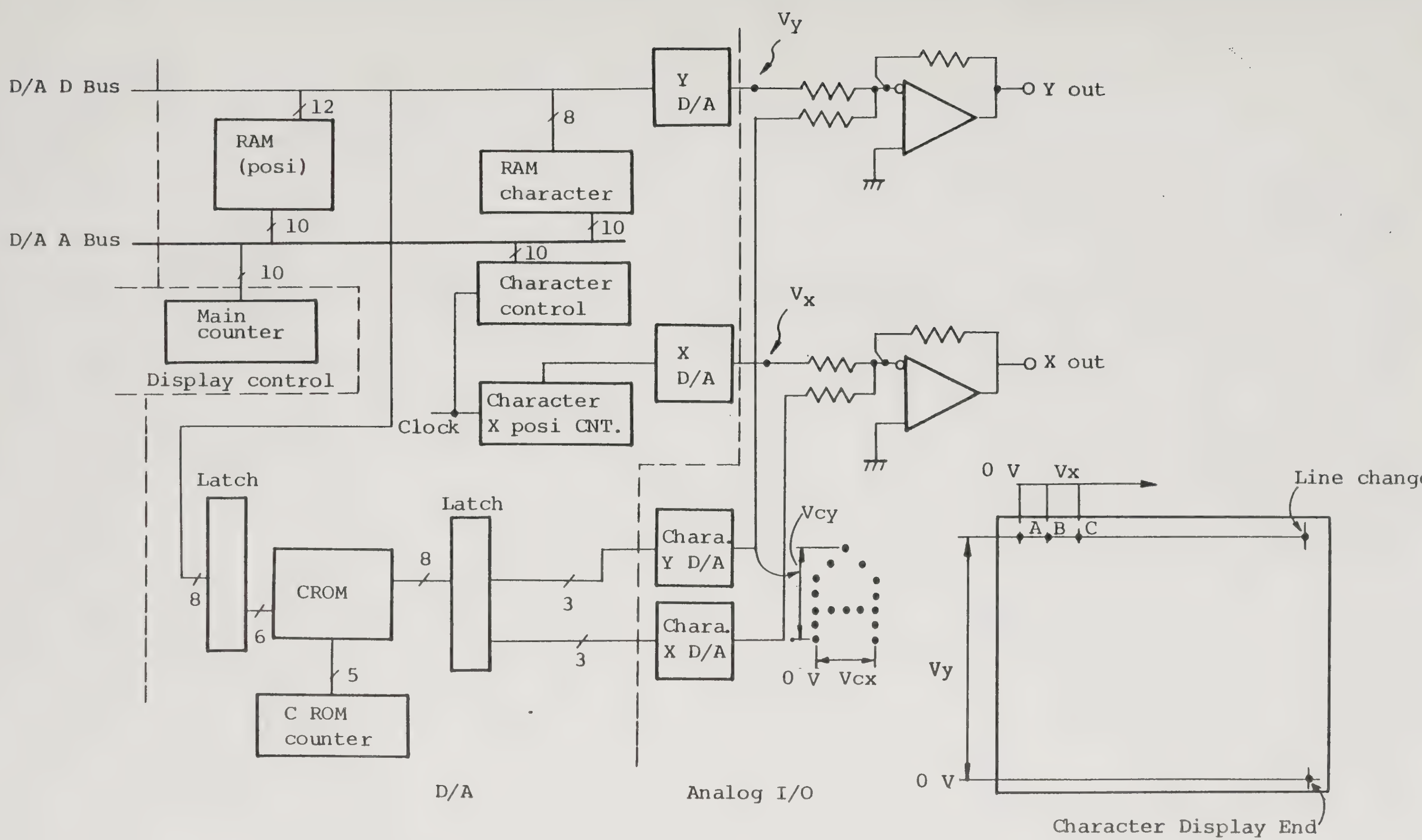


Fig. 10-23 Character display block diagram

When a character is to be displayed, the pertinent data is fetched from the RAM (position) on the D-A board to determine the Y axis position, is subjected to A-D conversion, and then output as Y OUT signal (V(y)). To determine the X axis position, output from the character X position counter output is subject to D-A conversion, and then output as X OUT signal (V(y)). Then, the pertinent character data is fetched from the character RAM. The character data causes the pertinent character to be read from the character ROM. The CX and CY data (each 3 bits) for character display are then output to the analog I/O board, where they are each subject to D/A conversion into Vcx and Vcy voltages, and added to Vx and Vy voltages to be shown on the display.

After this operation sequence is executed to all the characters to be displayed, the control proceeds with the next job fetch.

(2) Line display

Figure 10-24 shows a block diagram relating to line display. The line display shows the graticule (10 x 10) and display line on the display.

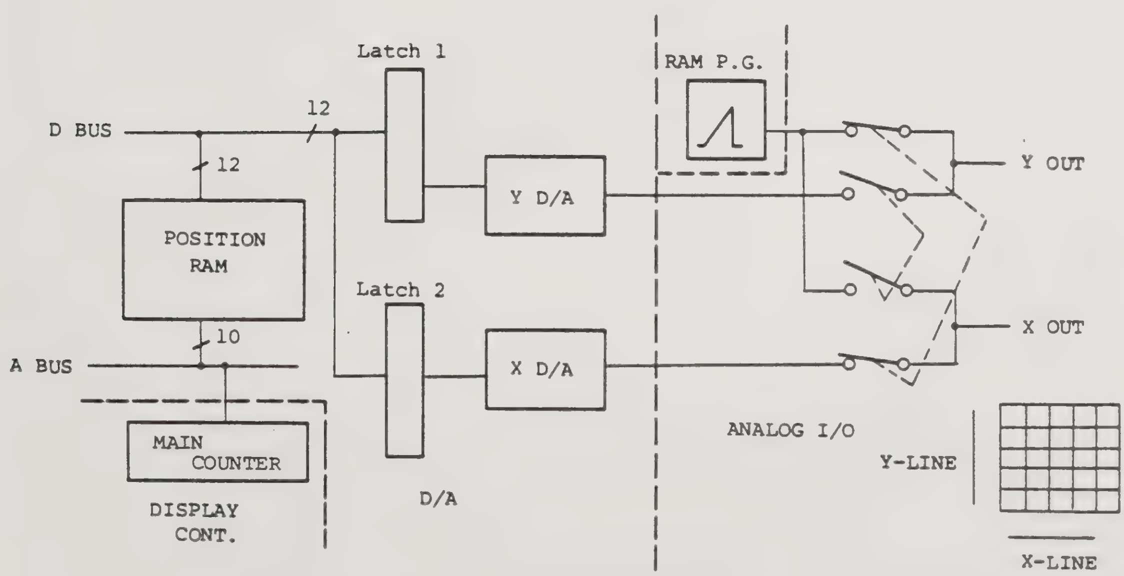


Fig. 10-24 Line display block diagram

When an X line is to be displayed, RAM (position) data is set into latch 1, is subjected to D-A conversion, and is output as Y OUT voltage to determine the Y line position. An X line can be displayed if the switch is operated so that a ramp voltage is output from the analog I/O board. The X line display sequence is repeated 10 times before the Y line is displayed. For Y line display, the RAM data is set into latch 2, is subject to D/A conversion, and is output to X OUT to determine the Y line operation. A ramp voltage is applied to Y OUT to display a single Y line. The Y line display sequence is repeated 10 times to display the complete graticule.

The display line can be obtained in much the same way as the X line display operation.

(3) Spectrum display

Figure 10-25 shows a block diagram relating to spectrum display.

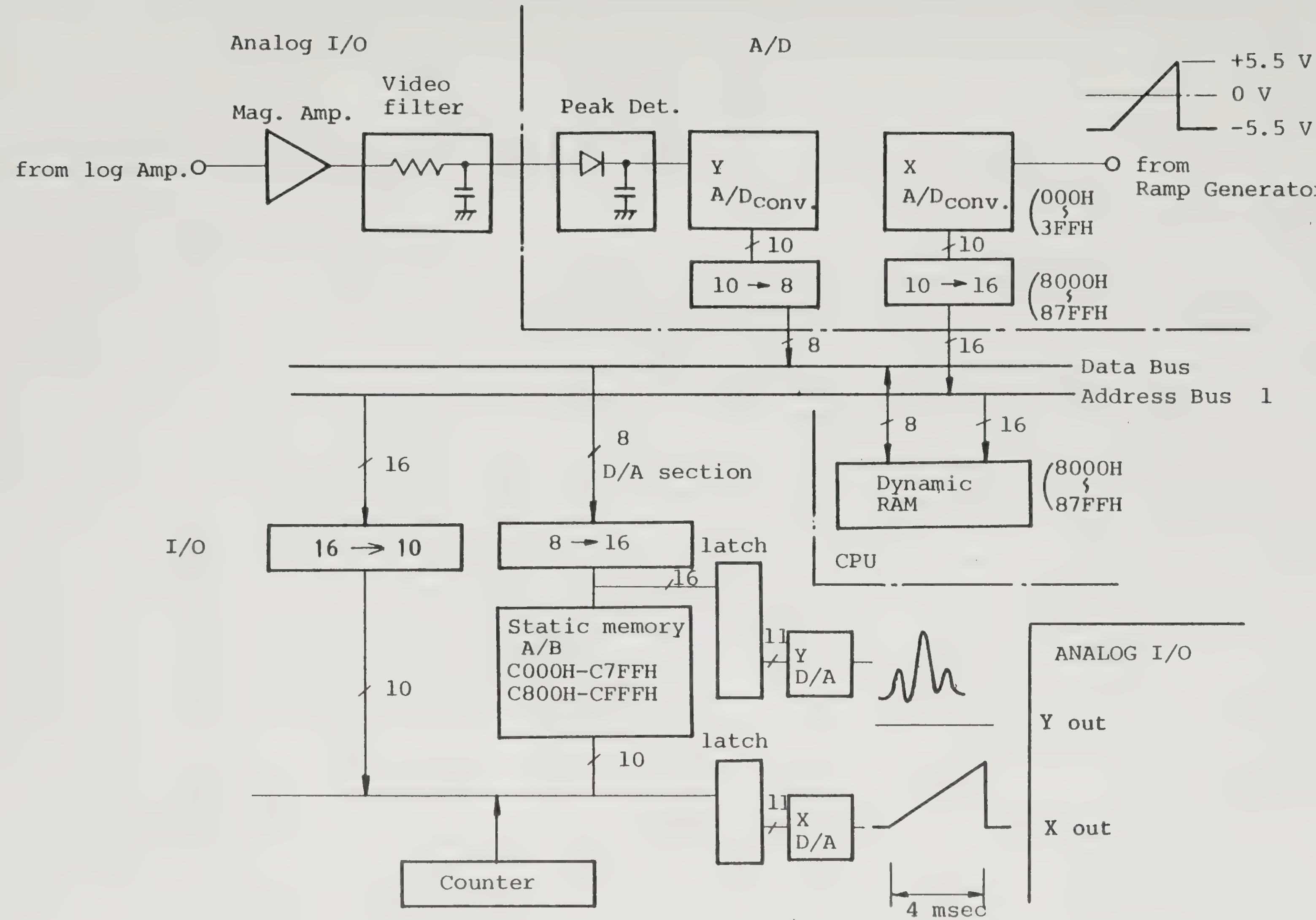


Fig. 10-25 Block diagram for spectrum display

The spectrum display mode is used for signal phase and response display. The X and Y signals which were subjected to A/D conversion on the A/D board, are first stored in the dynamic RAM on the CPU board, processed by CPU, then transferred to the static RAM on the D/A board. The static RAM includes memory A and B, either of which is selected according to panel setup. The contents of the RAM are set into X and Y latches, subject to D/A conversion, then output to the analog I/O board to be displayed.

(4) Graphic display

Figure 10-26 shows a block diagram pertaining to graphic display.

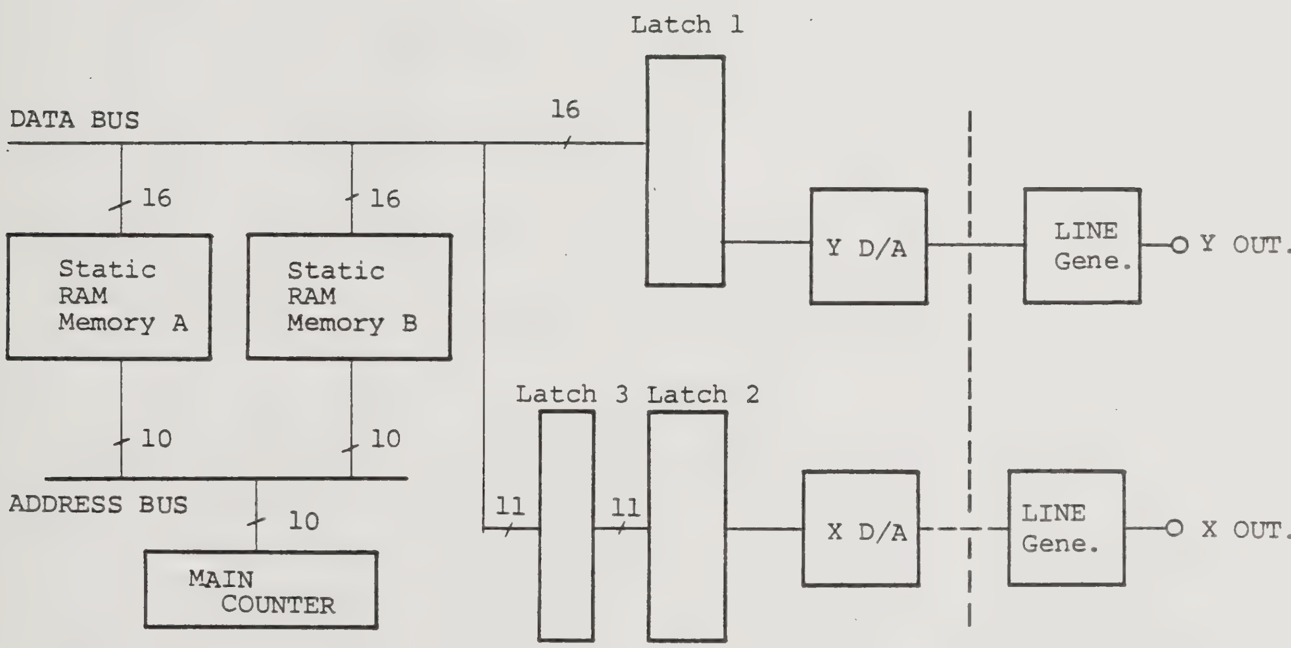


Fig. 10-26 Block diagram for graphic display

Two pages of graphic display are supported by memories A and B. Each memory holds X data at address 0=0 and Y data at address 0=1 respectively. Since each dot is assigned two bytes of data, the maximum number of data in one page is 512 points. X data is set into latch 3 when Address 0=0, while the contents of latch 3 is set into latch 2 when Address 0=1 and Y data is set into latch 2. Data set into each latch subject to D/A conversion to provide a single point of display on the CRT. The graphic display as shown in Figure 10-27 is obtained by repeating the above sequence.

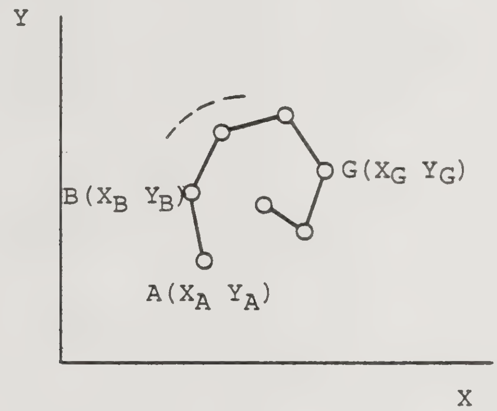


Fig. 10-27 Graphic display on the monitor

(5) Analog display

In the analog display mode, the video filter output on the analog I/O board is directly displayed on the monitor, with no digital processing performed on the display signal. This mode is effective only when zero frequency span and a sweep time of 19 ms or less is selected. It may be convenient to check the modulation signal component on the time axis.

SECTION 11

CALIBRATION AND ADJUSTMENT

11-1. GENERAL

This section describes the calibration procedure for the TR4172 Spectrum Analyzer. After the instrument is serviced, be sure to carry out performance check and calibration.
For quick part identification, the part numbers and symbols printed or inscribed on PC boards or schematic diagrams are used throughout this section.

11-2. PREPARATION AND GENERAL PRECAUTIONS

The tools and instruments required for calibration are listed in the following table. Use the recommended instruments in the list or their equivalents.

11-2-1. Tools and Instruments Required for Calibration

Table 11-1 Measuring instruments required

Instrument	Specifications	Recommended model
(1) Synthesized signal generator	Frequency range: 500 kHz to 1000 MHz Output level: +10 to -30 dBm Output impedance: 50 Ω Output level flatness: ±0.5 dB Frequency accuracy: 2 x 10^{-8}	
(2) Synthesized function generator	Frequency range: 1 Hz to 20 MHz Output level: +10 to -30 dBm Output impedance: 50 Ω Output level flatness: ±0.2 dB Frequency accuracy: Approx. 10^{-8}	
(3) Frequency counter:	Frequency range: Up to 4 GHz Input level: +20 to -30 dBm Input impedance: 50 Ω Frequency accuracy: 2 x 10-9	TR5211 (Takeda Riken)

Table 11-1 Measuring instruments required (Cont'd)

Instrument	Specifications	Recommended model
(4) Spectrum analyzer with tracking generator	Input frequency range: 100 kHz to 4 GHz Tracking generator output: 400 kHz to 2 GHz T.G. output flantness: ±1 dB Impedance: 50 Ω	TR4111A, TR4151 (Takeda Riken)
(5) Marker generator	Frequency: 1 MHz, 50 kHz, 5 kHz Full power: Approx. 0 dBm Impedance: 50 Ω	
(6) Power meter	Frequency range: 100 kHz to 1800 MHz Sensitivity: -30 to +20 dBm Accuracy: ±0.2 dB Impedance: 50 Ω	
(7) Digital voltmeter	Measurement range: 0V to ±1000 V Accuracy ±0.1%	TR6841 (Takeda Riken)
(8) High voltage probe	Voltage range: More than 20 kV Impedance: More than 1000 MΩ	TR1116 (Takeda Riken)
(9) Oscilloscope	Frequency: Approx.100MHz Sensitivity: 5mV	
(10) DC voltage standard	Output voltage: +15 V	
(11) High impedance probe	Measurement range: DC to 500MHz	
(12) Attenuator	Frequency range: DC to 500 MHz Attenuation: 0-100 dB at 10 dB steps 0-11 dB at 1 dB steps Accuracy: ±0.2 dB at 10 dB steps ±0.02 dB at 1 dB steps Impedance: 50 Ω	
(13) Scale		

Table 11-2 Jigs and tools required for adjustment

Item	Stock No.	Remarks
Input cable	MI-02	BNC-BUC (Short)*
Interconnecting cable	MI-61	BNC-BNC (Long)*
Interconnecting cable	MC-37	BNC-SMA
Interconnecting cable	MM-14	SMA-SMA
Interconnecting cable	MC-36	BNC-UM
Interconnecting cable	MM-17	UM-UM

Table 11-2 Jigs and tools required for adjustment (Cont'd)

Item	Stock No.	Remarks
N (P) to BNC (J) conversion adapter	JUG201	JNG-20A/U*
UM to UM linear adapter		UM-QA-JJ
SMA to SMA adapter		HRM-501
Extender board		(double, 28pins)
Extender board		(single, 22pins)
Extender board		(single, 28pins)

Items marked with an asterisk (*) are standard supply accessories.

11-3. PREPARATION

(1) The local line voltage at which the instrument should be operated is 100, 120, 200 Vac ±10% or 240 Vac +4%, -10% (50/60 Hz).

(2) Before connecting the instrument to an AC outlet, be sure to set the POWER switch to STANDBY.

(3) The calibration ambient temperature should be 20 to 30^{o}C at a relative humidity of less than 80%. The calibration site should be free from dust, vibration, and noise.

11-4. TIME BASE CALIBRATION

The time base oscillator contained in the analyzer is calibrated before shipment. The frequency standard used for calibration has an absolute accuracy of 1×10^{-10} (secondary factory standard). When checking or calibrating the time base oscillator accuracy, use a frequency standard having the frequency accuracy equivalent to or better than the above mentioned absolute value.

	Type A	Type B	Type C
Aging rate	5×10^{-9}/day	2×10^{-9}/day	5×10^{-10}/day
	5×10^{-8}/month	2×10^{-8}/month	1×10^{-8}/month
Long-term stability	8×10^{-8}/year	5×10^{-8}/year	2×10^{-8}/year
Temperature characteristic (0^{o}C to 50^{o}C)	$\pm 5 \times 10^{-8}$	$\pm 1 \times 10^{-8}$	$\pm 5 \times 10^{-9}$

Instruments required: Frequency standard (with absolute accuracy of more than 1×10^{-10}

Frequency comparator

(1) The time base oscillator output has a 10 MHz frequency and a level of approximately 5 V (TTL compatible). When [SHIFT] [LABEL] [7] keys are pressed subsequently, the oscillator output is output at the INT. STD. OUTPUT (J4) connector on the rear of the instrument. The frequency accuracy of the oscillator output can be adjusted by the STD ADJ. screwdriver adjustment next to the J4 connector.

(2) Prepare the measuring system as Figure 11-1, and adjust the STD ADJ. until the accuracy of each type of instrument is determined.

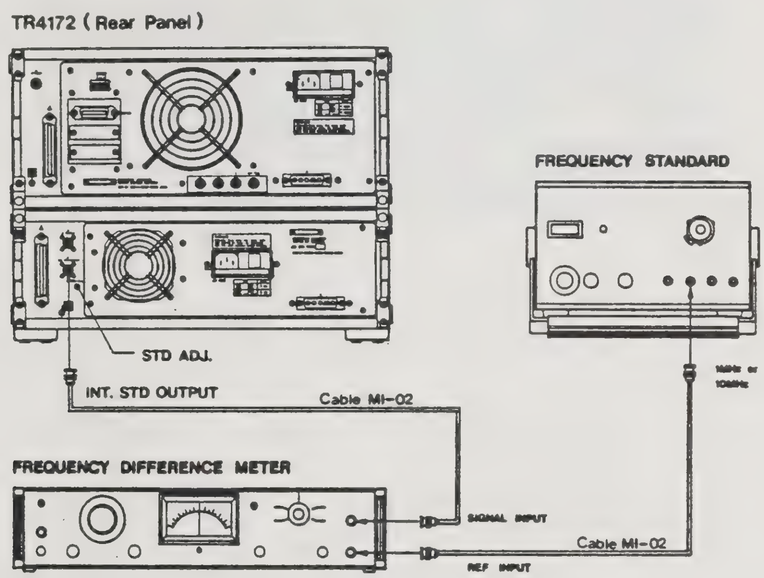


Fig. 11-1 Time base calibration

11-5. DISPLAY SECTION ADJUSTMENT

This paragraph describes the display section adjustment procedure.

11-5-1. Supply Voltage Adjustment (Board No. BGC-010198) (Circuit diagram No. 5)

Instrument required: Digital voltmeter

(1) Set the POWER switch to ON, and check the supply voltage at each point. The location of voltage adjustment and test points are shown in Figure 11-2.

(2) Using the voltage adjustments corresponding to each test point, adjust supply voltage until within specifications listed in Table 11-3.

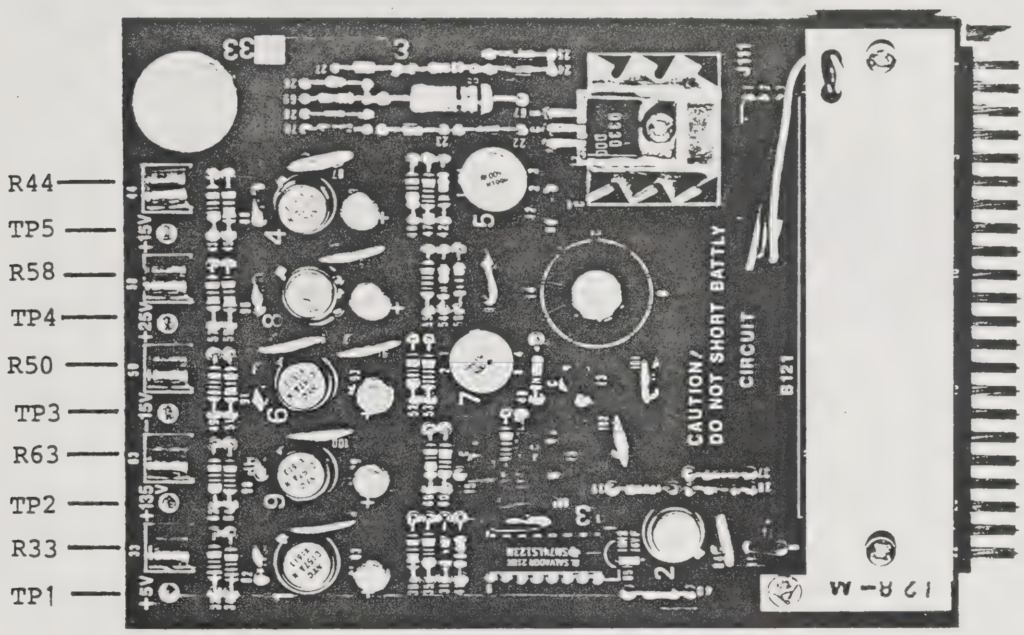


Fig. 11-2 Supply voltage adjustments and test points on the DISPLAY POWER 1 board (BGC-010198)

Table 11-3

Test point	Voltage	Adjustment
TP-4	+25 V ±0.01 V	R58
TP-5	+15 V ±0.01 V	R44
TP-2	+135 V ±0.2 V	R63
TP-3	-15 V ±0.01 V	R50
TP-1	+5 V ±0.05 V	R33

11-5-2. High Voltage Unit Adjustment and Check (BLC-0101204)

(Circuit diagram No. 9)

Instruments required: Digital voltmeter

High voltage probe

(1) Set the POWER switch to STANDBY.

(2) Remove phase block (MEP-339) from the instrument. (See Figure 11-3.)

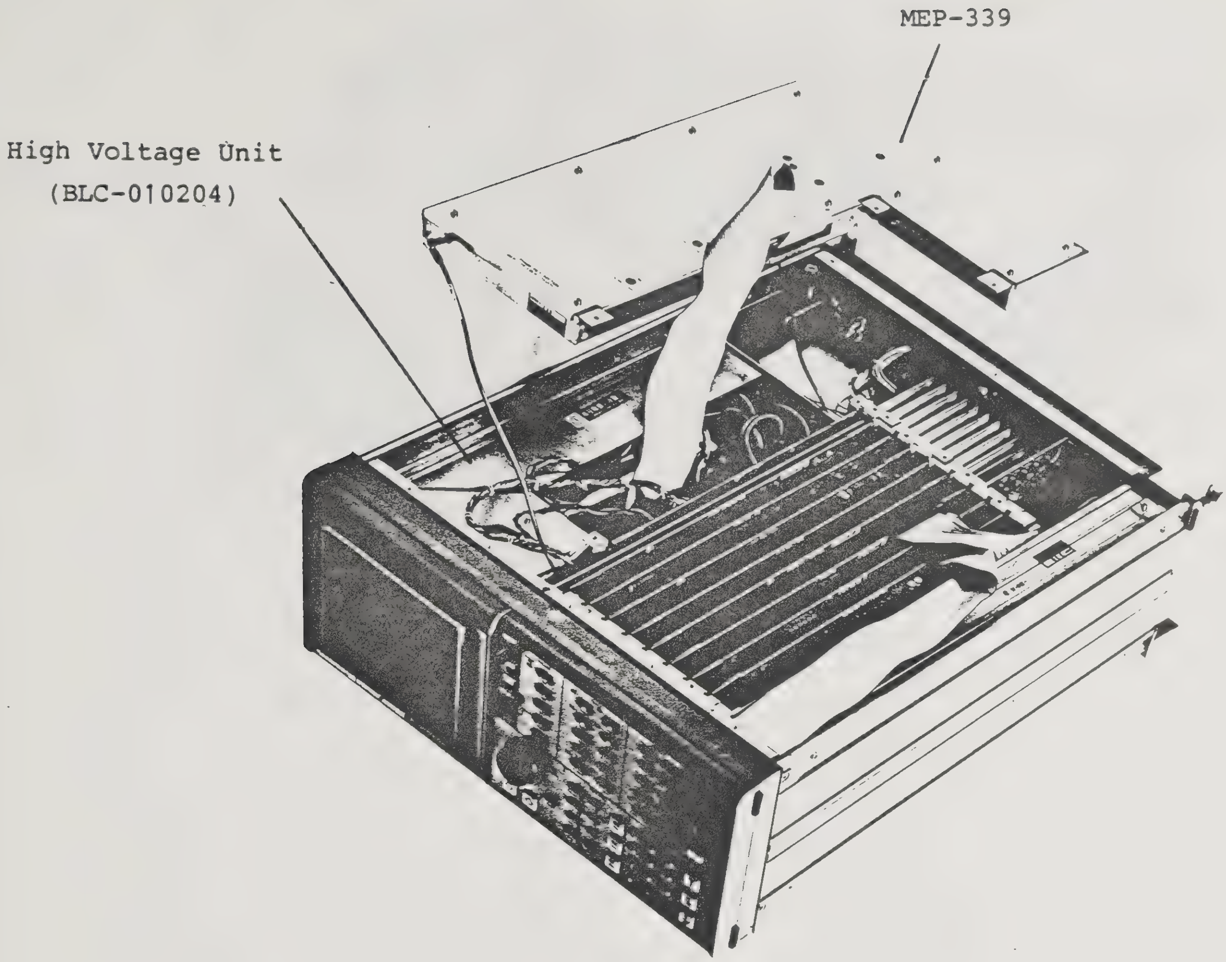


Fig. 11-3 Removing the phase block (MEP-339)

(3) Remove the High Voltage Unit (BLC-010204) from the display section, then temporarily secure it to the top left edge of the case as shown in Figure 11-4.

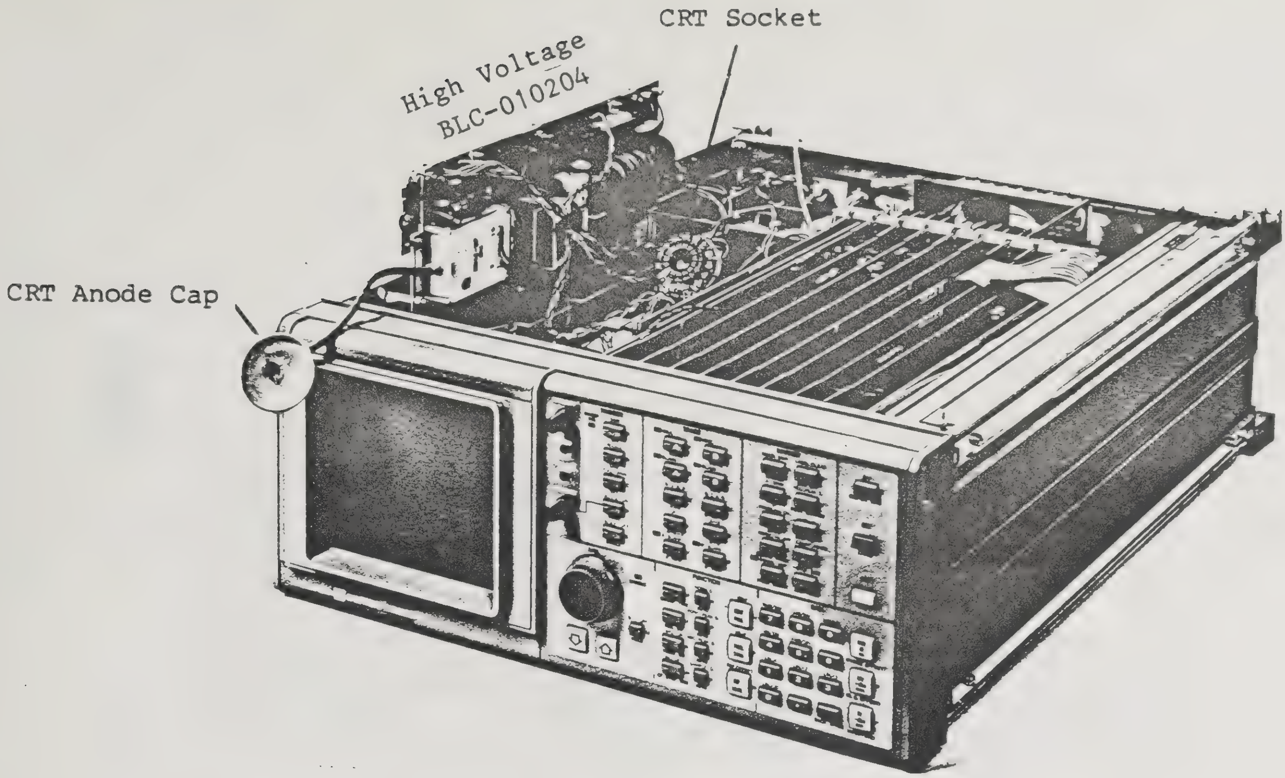


Fig. 11-4 Adjusting high voltage unit

(4) Disconnect the CRT anode cap and CRT socket from the CRT. High potential charges may remain at the anode cap or CRT socket. Exercise utmost caution to avoid electrical shock. Leave all connectors other than the anode cap and CRT socket connected in their original sockets.

(5) After verifying that neither the anode cap nor CRT socket is in contact with the chassis or other components, set the POWER switch to ON.

(6) Adjust R62 until the voltage across the test point TP K and the GND (chassis) is -3.000 kV. Use a high voltage probe and a digital voltmeter for voltage check. Be sure that the impedance of the high voltage probe matches the input impedance of the digital voltmeter.

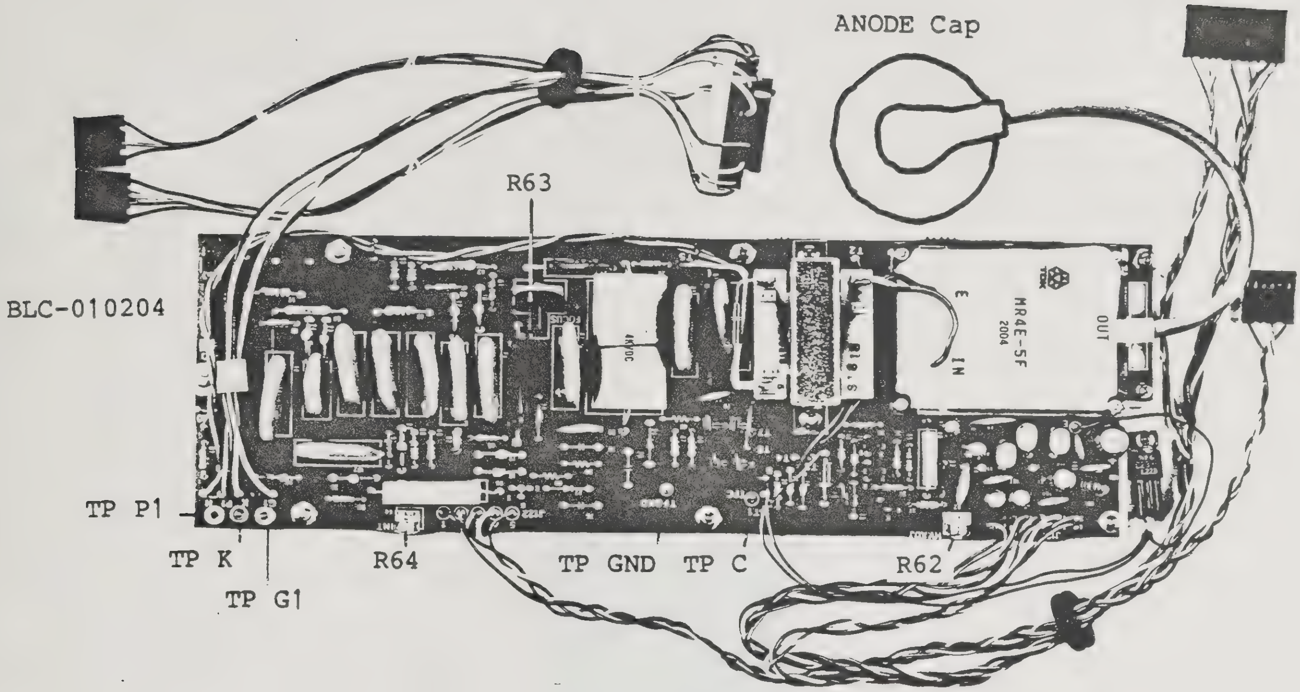


Fig. 11-5 Adjustments and test points on the high voltage unit (BLC-0101204)

(7) Verify that the voltage across the anode cap and the GND (chassis)is +12 to +13 kV. While checking this voltage, exercise caution to avoid electrical shock.

(8) Set the POWER switch to STANDBY. While monitoring the anode cap voltage with the digital voltmeter, discharge the anode cap.

(9) After verifying that the anode cap potential is lowered to the safety voltage, connect it to the CRT.

(10) Remount the high voltage unit (BLC-0101204) at its original position in the chassis, then connect the CRT socket to the CRT. Remount the phase block to its original position in the chassis.

11-5-3. CRT Driver and Bias Adjustment (Board: BGK-010184)
(Circuit diagram No. 10)

Instrument required: Oscilloscope
Digital voltmeter

(1) Set the POWER switch to STANDBY. Pull out the CRT driver board (BGK-010184) and remount it in the same slot using an extender board (28 pins,single). The cables to the on-board connectors J281 and J282 should be connected to the board by extender cables. Set the POWER switch to ON.

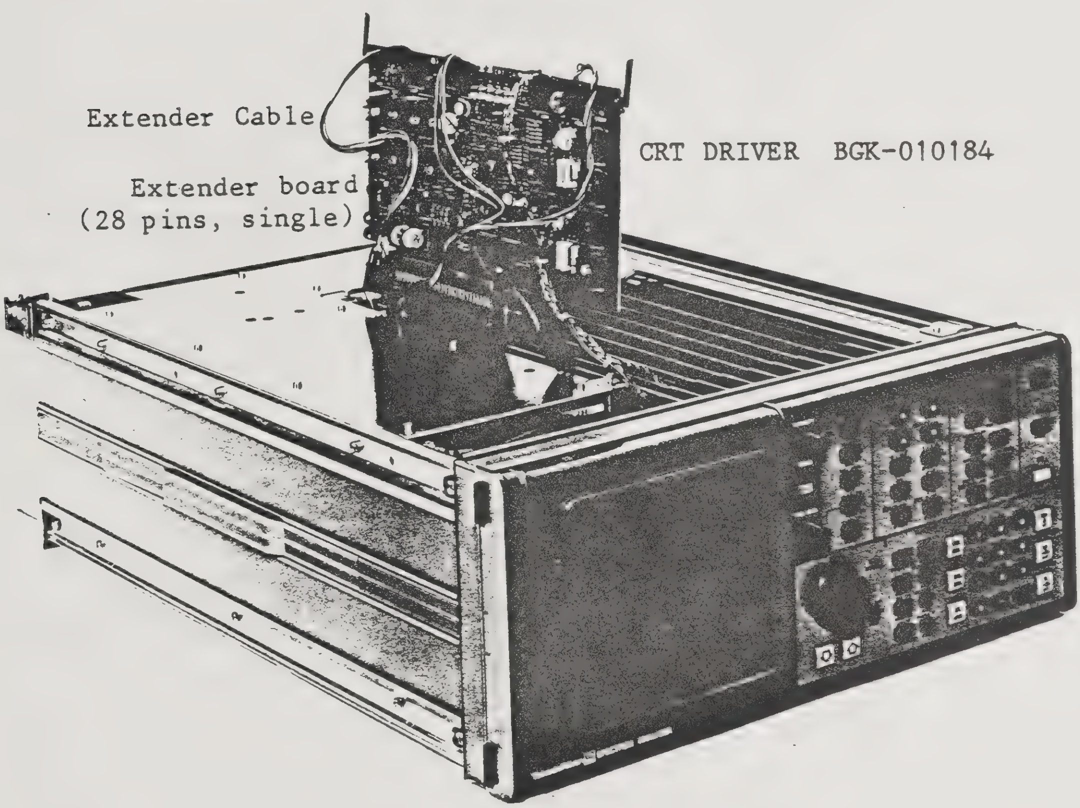


Fig. 11-6 Adjusting setup using an extender board

(2) Check the voltages at pins 1 and 5 of on-board connector J182 with a digital voltmeter. Adjust R203 and R199 until the voltage at each pin is +75 V.

(3) Turn the INTENSITY control on the front panel of the display section completely clockwise to obtain maximum display intensity. Adjust R202 so the display is not subject to halation due to secondary electron radiation.

(4) Adjust R200 until pattern distortion is minimized.

(5) Place the standard pattern scale (included in the maintenance kit) on the display screen, and adjust the display gain and position. The gain and position adjustments for the axis are R193 and R192 respectively, and those for the X axis are R195 and R194 respectively.

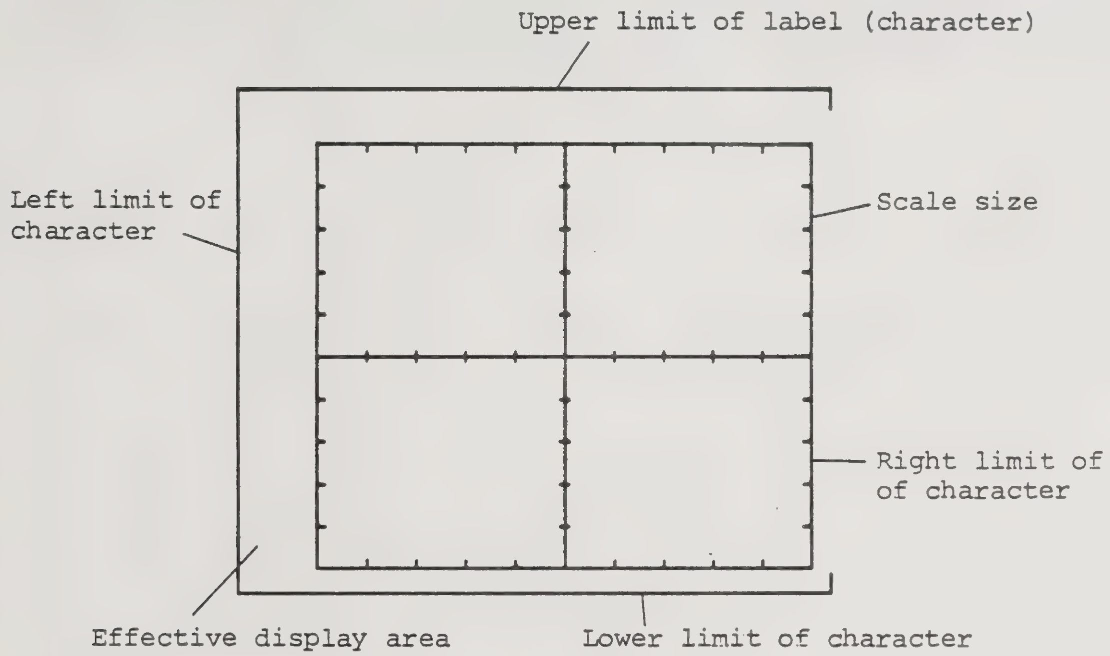


Fig. 11-7 Standard display scale (MPH-20803A)

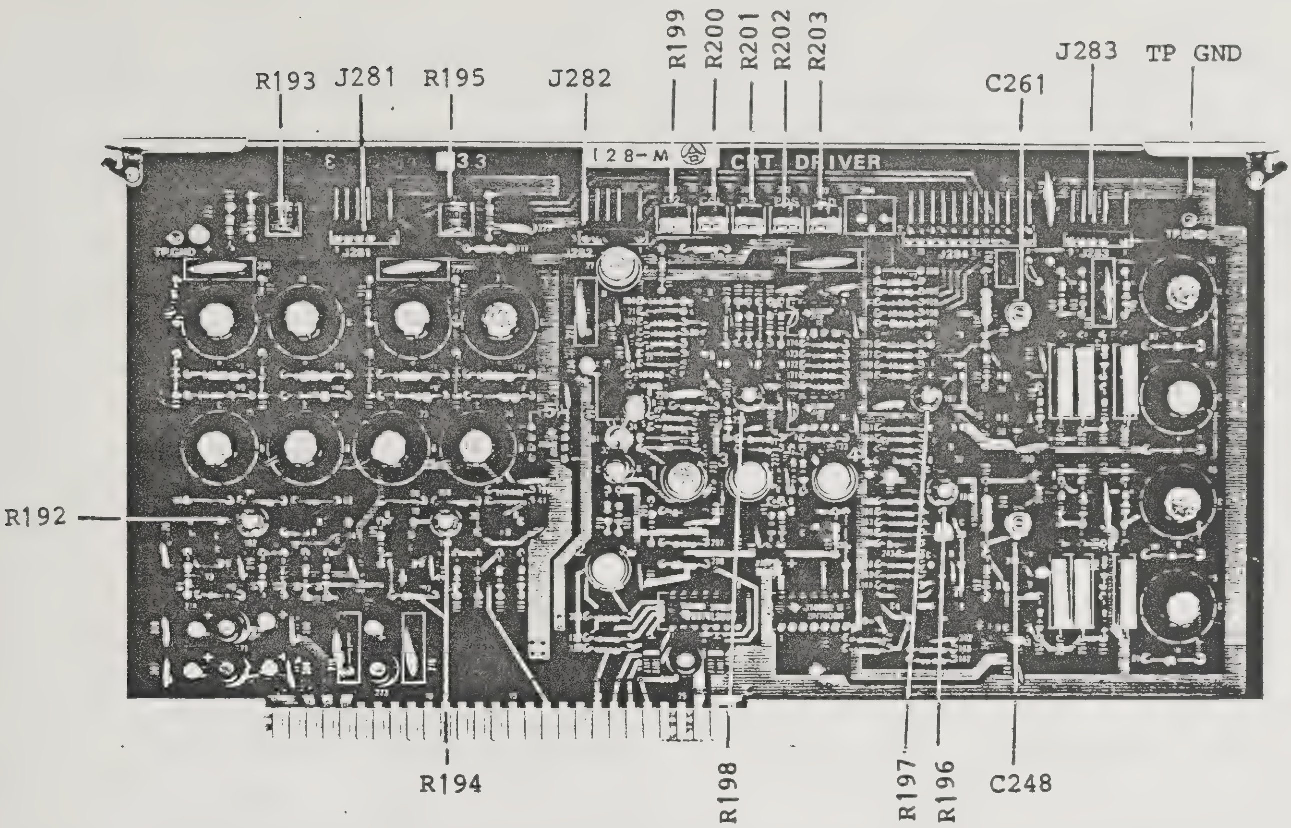
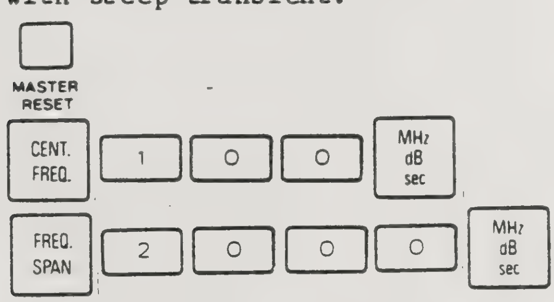


Fig. 11-8 Adjustment and test points on the CRT driver board (BGK-010184)

(6) Use the following key operations to obtain a signal response with steep transient:



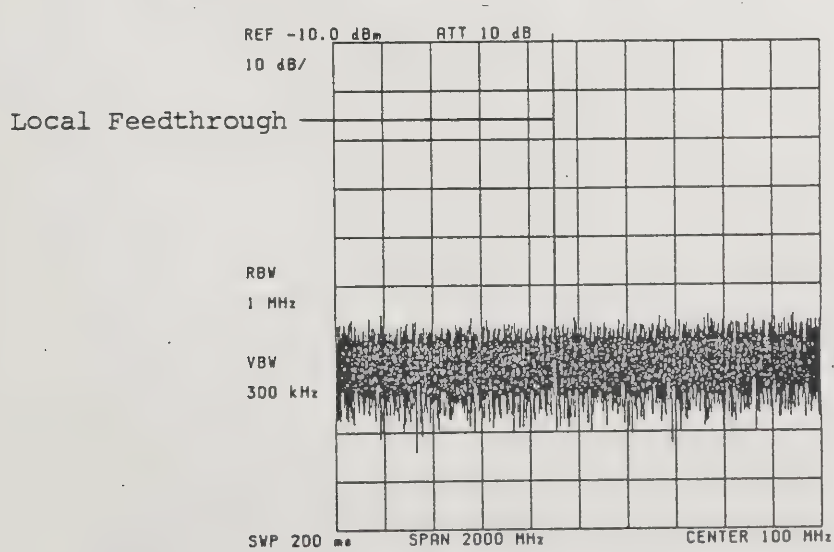


Fig. 11-9 Signal response display for intensity adjustment

(7) Set INTENSITY control on the front panel to the center position. Adjust R64 on the high voltage unit (MEP-0101204) and R196 on the CRT driver board (BGK-010184) until the signal response trace is slightly visible on the display. At this time, R64 should be turned toward low intensity, while T196 should be turned toward high intensity.

(8) Set the FOCUS screwdriver adjustment on the front display section to the center position. Adjust R63 on the high voltage unit and R201 on the CRT Driver board until the center of the display is well focused.

(9) Adjust R197 on the CRT Driver board until a good focus is obtained for the local feedthrough on the display.

(10) Adjust R198 so a good focus is obtained for the left and right areas of the display.

(11) While observing the signal at pin 1 of J283, adjust C248 until the waveform has no overshoot. Similarly, adjust C261 until the waveform at pin 3 of J283 has no overshoot. Connect the probe ground for the oscilloscope to a TP-GND on the board.

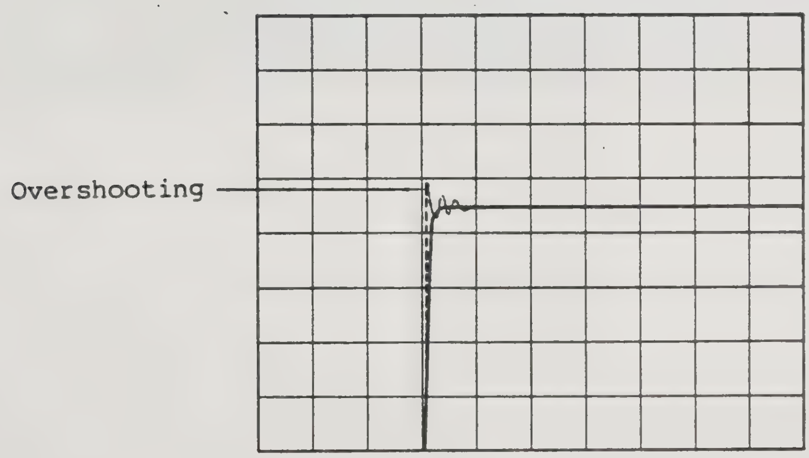


Fig. 11-10 Overshoot

(12) Set the POWER switch to STANDBY. Return the CRT Driver board (BGK-010184) into its original slot. Set the POWER switch to ON.

11-5-4. Data knob adjustment (Board: BGP-010192)
(Circuit diagram Nos. 21, 22)

Required instrument: Oscilloscope

(1) Using the oscilloscope, check the signals at TP2 and TP4 on the Memory board (BGP-010192).

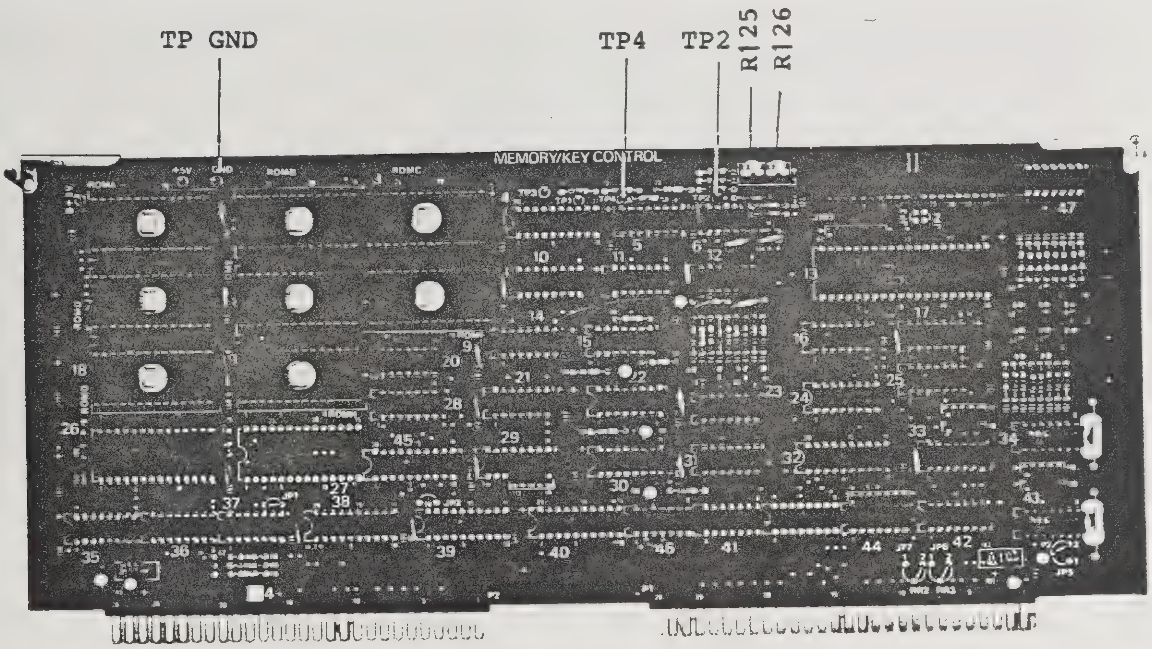


Fig. 11-11 Locations of Memory board (BGP-010192) check points

(2) Turn the front DATA knob at a constant speed, and adjust R125 and R126 until the signal waveforms at TP2 and TP4 have a duty ratio of 1:1.

11-5-5. D-A converter +10 V adjustment (Board: BGP-010188)

(Circuit diagram No. 14)

Instrument required: Digital voltmeter

(1) Set the POWER switch to STANDBY. Pull out the D-A Converter board (BGP-010188), then remount it in the same slot using an extender board (double 28 pins).

(2) Set the POWER switch to ON. Check the emitter voltage of Q61 on the board with a digital voltmeter. Adjust the collector voltage to +10 V ± 10 mV with R91.

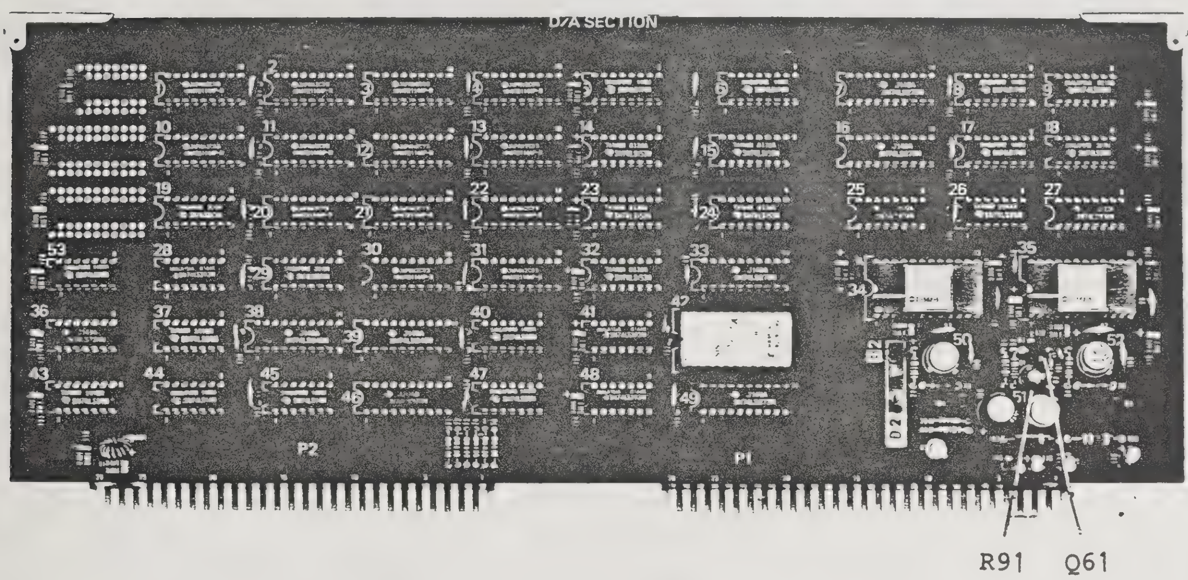


Fig. 11-12 Adjustment on the D-A converter board (BGP-010188)

(3) Set the POWER switch to STANDBY, and return the board to its original slot (without extender board). Then set the POWER switch again to ON.

11-5-6. Ramp Generator Adjustment (Board: BGP-010185)

(Circuit diagram No. 11)

Instrument required: * Digital voltmeter
* Function generator
* Oscilloscope

(1) Set the POWER switch to STANDBY. Pull out the ramp generator board (BGP-010185), then remount it in the same slot using an extender board (double 28 pins).

(2) Set the POWER switch to ON. Connect the oscilloscope to the card-edge connector pin P1-9AB (RAMP OUT), and adjust R95 until the output ramp signal has a 0 V ±5 V amplitude.

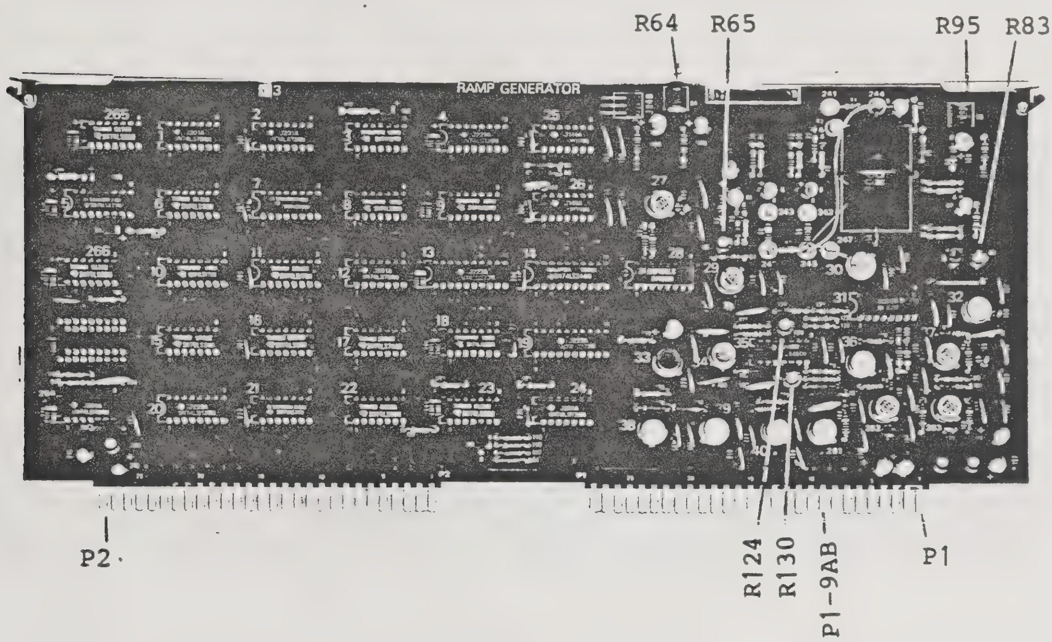


Fig. 11-13 Adjustments on the ramp generator board (BGP-010185)

(3) Set the POWER switch to STANDBY. Pull out the Analog I/O board (BGP-010186), and remove the jumper wire from JP1. Connect the function generator output to the LOG test point.

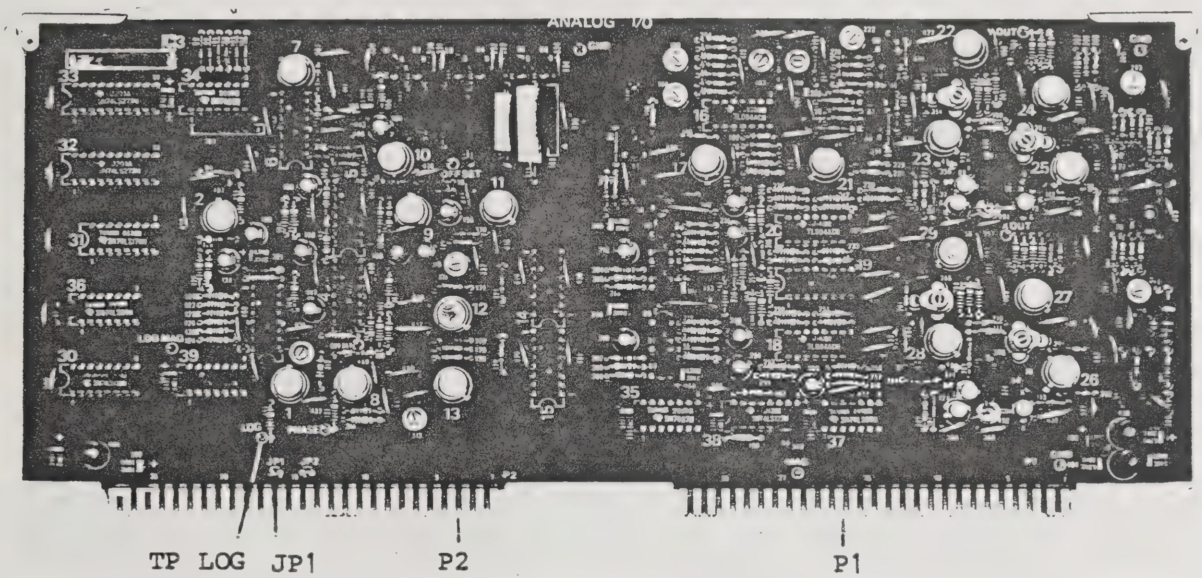
(4) Remount the analog I/O board in its original slot, then set the POWER switch to ON.

(5) Set the function generator output to 500 Hz, +2 Vp-p in level, and sinewave. Set the sweep time of the analyzer to 20 ms. Adjust R64 on the ramp generator board so that 10 cycles of sine wave exist within the scale span on the screen.

(6) Set sweep time to 2 sec. Set the function generator output frequency to 5 Hz. Adjust R65 on the Ramp Generator board (BGP-010185) so 10 cycles of sine wave appear within the scale span on the screen.

(7) Press [SHIFT] [ZERO SPAN ⇧] to select zero frequency span. Set sweep time to 500 μsec. Set the function generator output frequency to 20 kHz. Adjust R83 so that 10 cycles of sine wave appear within the scale span on the display.

(8) When R64 is readjusted, also readjust R65 and R83.



Analog I/O (BGP-010186)

Fig. 11-14 Connecting a function generator output to the analog I/O board

(9) Adjust analog sweep. Set the output frequency of the function generator to 100 Hz. Set sweep time to 19 ms. Adjust R124 until the signal response on the display is centered on the vertical center scale.

(10) Adjust rewriting position. Set sweep time to 10 sec. Adjust R130 until the trace rewriting position coincides with the blanking position at the center of the screen.

(11) Set the POWER switch to STANDBY. Disconnect the function generator output from the analog I/O board, and install the jumper wire at JP1. Return the analog I/O and ramp generator boards to their original slots, then set the POWER switch to ON again.

11-5-7. Analog I/O Board Adjustment (Board No. BGP-010186)
(Circuit diagram No. 12)

Instrument required: * Digital voltmeter (4 and a half digits.)
* Standard DC voltage source
* Function generator

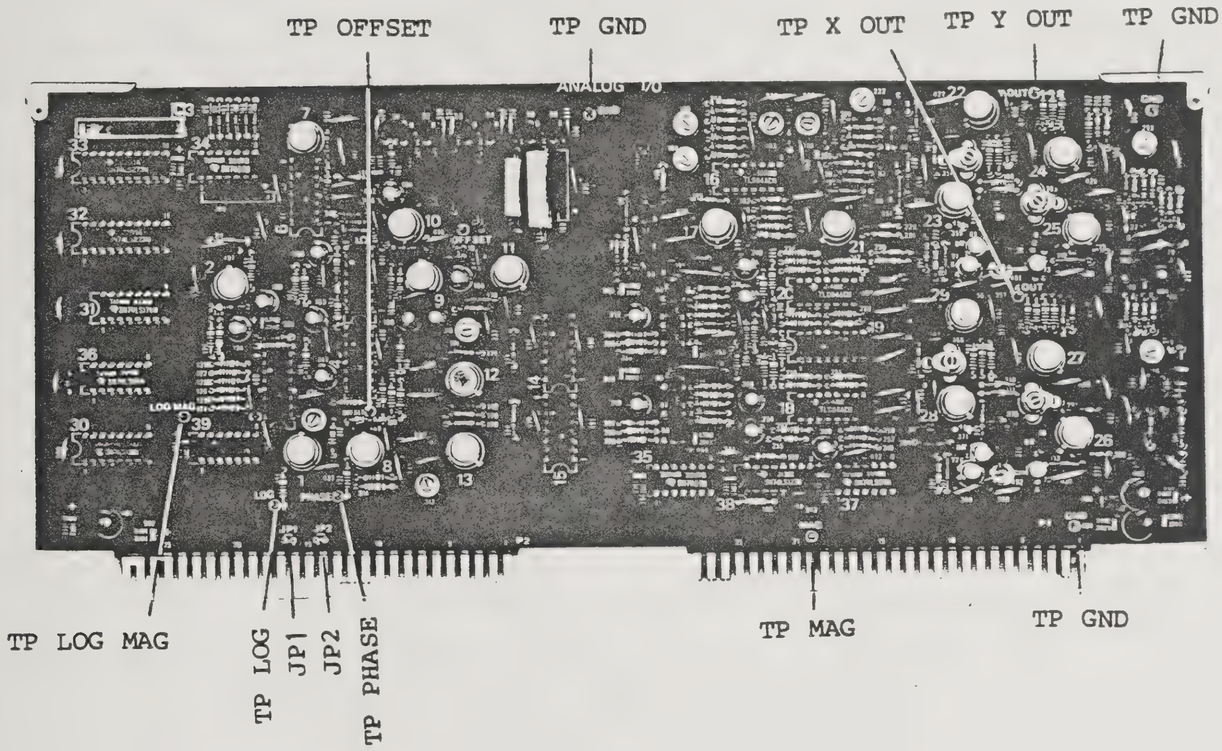


Fig. 11-15 Locations of adjustments and test points on the analog I/O board (BGP-010186)

(1) Set the POWER switch to STANDBY. Pull out the Analog I/O board (BGP-010186), and remove jumper wires from JP1 and JP2. Remount the board in the same slot using an extension card (double 28 pins).

(2) Connect the output of a standard DC source across the LOG test point and a GND test point. Set the voltage source output to 0.000 V, then set the POWER switch to ON.

(1) Adjusting the MAG. amplifier for logarithmic display

(a) Check the voltage across the test point log mag and a GND test point with a digital voltmeter. Press SHIFT, 1dB/DIV. to set the vertical scale to 1 dB/div. Adjust R311 until the voltmeter reading (offset voltage of the first operation amp.) is less than 50 µV.

(b) Press SHIFT, 10dB/DIV. to set the vertical to 10 dB/div. Check the voltage across the test point MAG and GND (test point). Set standard DC output to 2.5 V. Adjust R134 until the voltage is 2.5 V ±5 mV.

(c) Set standard DC output to 0.000 V. Adjust R130 until the voltmeter reading is 5.000 V ±5 mV.

(d) Repeat steps (b) and (c) several times.

(2) Adjusting the MAG. amplifier for phase display

(a) Set the output of standard DC to 0.000 V. Disconnect it from the log test point and reconnect it to the phase test point.

(b) Press MASTER RESET, FREQ. SPAN 1 0 MHz dB sec and GROUP DELAY, then use the DATA knob to set the vertical scale to 20 ns/div. Check the voltage across the offset test point and GND (test point) (offset voltage of the first operation amp.). Adjust R315 until the offset voltage is less than 50 µV.

(c) Check the voltage at the test point MAG to GND. Adjust R164 until the voltage is +2.500 V ±5 mV.

(d) Set the standard DC output to +400 mV, and adjust R158 until the voltmeter reads +5.100 V ±5 mV.

(e) Set the output of standard DC to -400 mV, and verify that the voltmeter reading is -0.100 V ±5 mV.

(f) Press PHASE to select 8°/div. Set the standard DC output to +400 mV. Adjust R156 until the voltmeter reads +4.750 V ±5 mV.

(g) Use the DATA knob to select 20°/div. Set the standard DC output to +1.000 V. Adjust R147 until the voltmeter reads +4.750 V ± 5 mV.

(h) Use the DATA knob to select 40°/div. Set the standard DC output to +2.000 V. Adjust R150 until the voltmeter reads +4.750 V ±5 mV.

(i) Use the DATA knob to select 80°/div. Adjust R153 until the voltmeter reads +3.625 V ±5 mV.

(3) Scale position adjustment

(a) Adjust R183 so the bottom end of the vertical scale is aligned to the bottom graticule of the horizontal scale.

(b) Adjust R190 until the left end of the horizontal scale is aligned to the leftmost graticule of the vertical scale.

(c) Adjust R180 until the top end of the vertical scale is aligned to the top graticule of the horizontal scale.

(d) Adjust R188 until the right end of the horizontal scale is aligned to the rightmost graticule of the vertical scale.

(4) Character size and position adjustment

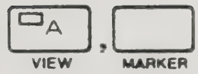
(a) Place the standard pattern scale shown in Figure 11-7 (used for x-and y-axis adjustment) on the display screen.

(b) Make the following adjustments until each character location is aligned to the standard pattern scale:
R236 for character position on the y-axis.
R240 for y-axis gain.
R256 for character position on the X-axis.
R254 for x-axis gain.

(5) Line generator adjustment

(a) Disconnect standard DC output from PHASE and GND test points, to which it was connected during the adjustment of the MAG. amplifier for phase measurement. Connect the function generator across LOG and GND test points.

(b) Press [MASTER RESET], [SWEEP TIME] [1] [.] [5] [MHz dB sec] to set sweep time to 1.5 s. Set the function generator output to 500 Hz, 2 Vp-p, with DC offset of 1.3 V.

(c) Press 

, and turn the DATA knob slightly. The marker will move vertically. Adjust C354 so the marker traces the signal response on the display.

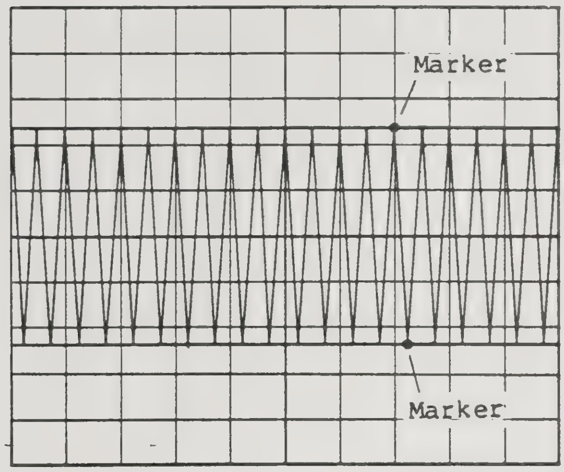
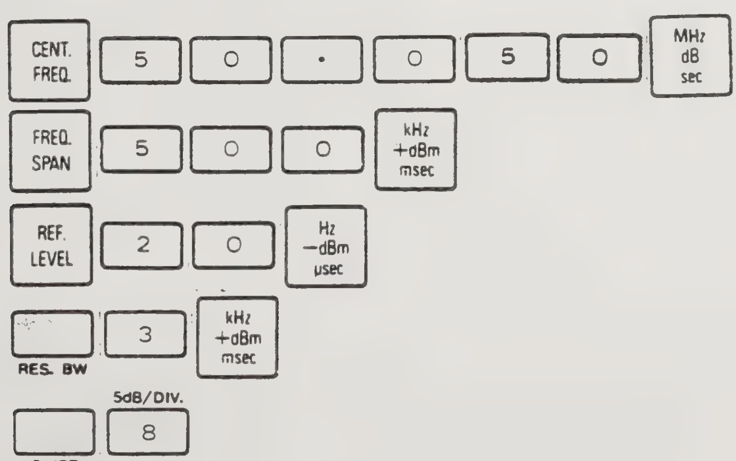


Fig. 11-16 Marker level adjustment

(d) Disconnect the function generator from the LOG and GND terminals, and set the POWER switch to STANDBY. Install jumper wires on JP1 and JP2, then switch the analyzer on again.

(e) While the instrument is in the initial default state, prepare it as follows:



(f) Connect the CAL. OUT. connector to the INPUT-1 connector to display the CAL. OUT. signal response. Adjust C375 until a smooth and straight response trace is obtained.

Adjust so the signal response
is smooth and free of ripples.

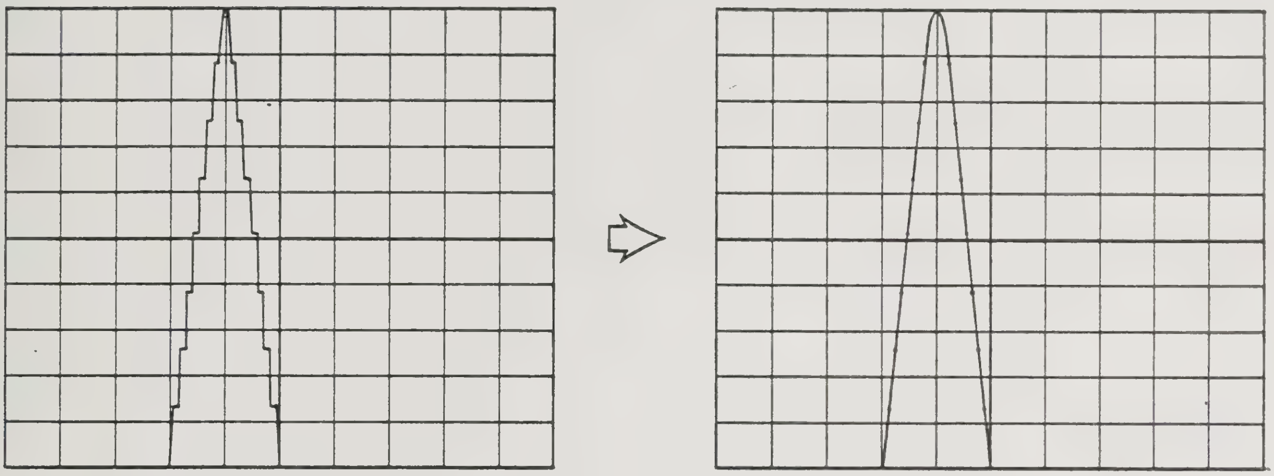
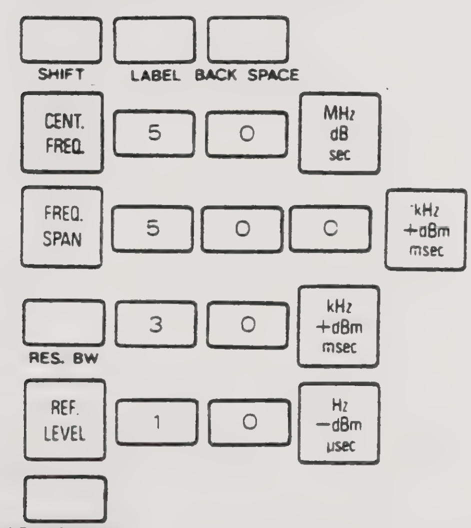


Fig. 11-17 Line generator adjustment 1

(g) Update the panel setup on the instrument as follows:



(h) Adjust the CAL control on the front panel of the analyzer until the level readout identified by the marker is exactly -20.0 dBm.

(i) Press MKR OFF, and adjust C363 until the signal response peak is positioned on the horizontal scale at -20 dBm.

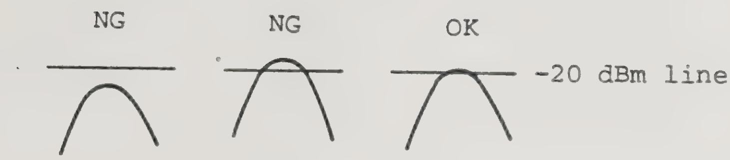
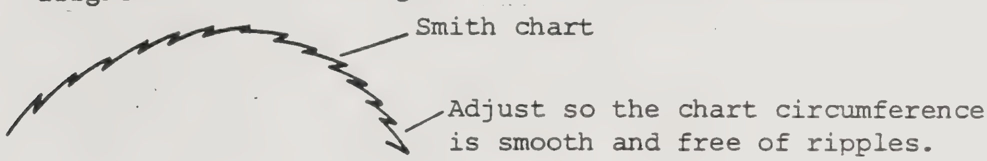


Fig. 11-18 C363 adjustment

(j) Adjust line generator in the graphic mode (S parameter display). Disconnect the CAL. OUT. from the INPUT-1 connector. Press 

to select the S parameter display mode. Adjust C366 until a smooth circumference line (for a Smith chart, for example) is obtained. Then adjust the horizontal position of the Smith chart with R309 until the center position of Smith chart is aligned to the center graticule of the vertical scale.



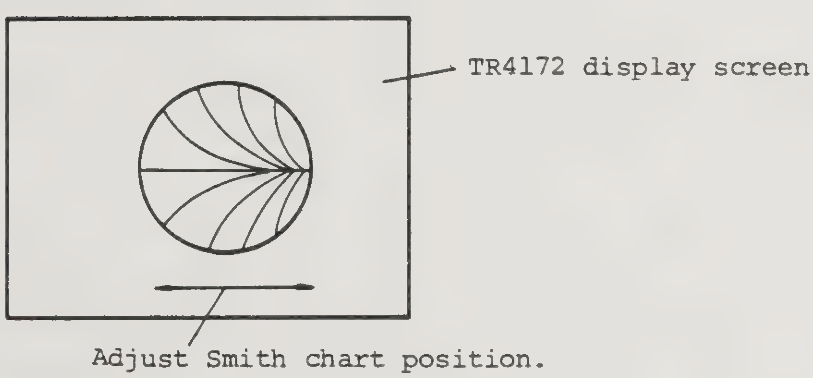


Fig. 11-19 Line generator adjustment (position)

(6) Marker size adjustment

Press 

to activate the marker. Adjust R293 and R306 until a round marker dot is obtained.

Fig. 11-20 Marker adjustment

(7) Analog sweep positional adjustment

(a) Press [SHIFT] [ZERO SPAN ⇧] to select zero frequency span. Press [SWEEP TIME] [2] [0] [kHz +dBm msec], then use [⇩] to set sweep time to 10 ms.

(b) Analog sweep mode is selected instead of digital sweep mode when the step down switch is pressed. The signal response trace will be verticary displaced slightly when the sweep mode is switched from digital to analog. Adjust R174 until the trace is repositioned to its original position.

(c) Set the POWER switch to STANDBY. Mount the analog I/O board in its original slot (without extension card), then switch on the instrument again.

11-5-8. A-D Converter Board Adjustment (Board: BGP-010187)

(Circuit diagram No. 13)

Instruments required: * Digital voltmeter (4 and a half digits.)
* Standard DC voltage source
* Function generator

(1) Set the POWER switch to STANDBY. Pull out the A-D Converter board (BGP-010187), and remove the jumper wire from JP1. Remount the board in the same slot using an extension card (double 28 pins).

(2) Connect the standard DC output across the test points TP1 and GND. Set standard DC output to 5.000 V, then set the POWER to ON.

(3) Use the digital voltmeter to check the voltage across test points TP4 and GND. Set sweep time to 10 sec.

(4) Press SHIFT SAMPLE D. z to select sample detection mode. Adjust R177 until the voltage at TP-4 is +5.000 V ±1 mV.

(5) Press SHIFT POSIT. PEAK D. p to select positive peak detection mode. Adjust R178 until the voltage at TP-4 is +5.000 V ±1 mV.

(6) Press SHIFT NEG. PEAK D. s to select negative peak detection mode. Adjust R176 until the voltage at TP-4 is +5.000 V ±1 mV.

(7) Set the standard DC output to 0.000 V. Set the reference level to 0 dBm. Press MARKER, and adjust R179 until the marker reading is -100.0 dBm ±1.0 dBm.

(8) Set standard DC output to +5.000 V. Adjust R180 until the marker reading is 0.0 dBm +0.1 dBm. Repeat steps (7) and (8) several since R179 and R180 affect each other.

(9) Disconnect standard DC from test points TP-1 and GND and instead connect the function generator output across TP-1 and GND. Set the function generator output to 100 Hz per 100 Hz triangular wave 2 Vp-p, output level, and 1.3 V DC offset.

(10) Connect oscilloscope across pin 9 of IC10 and GND, and adjust R175 until obserbed signal waveform stops flickering.

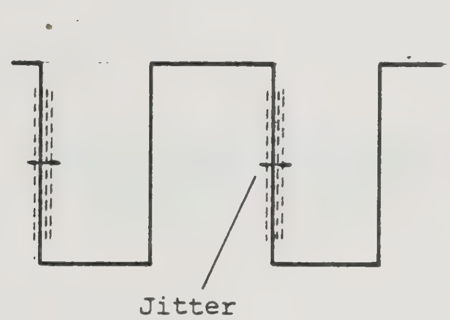
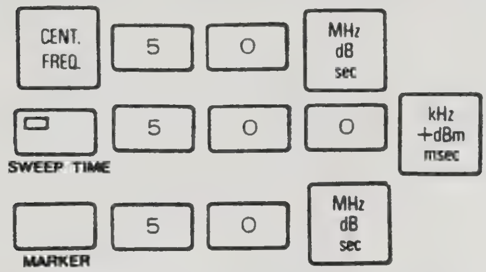


Fig. 11-21 Adjusting R175 on the A-D converter board

(11) X-axis center adjustment. Set POWER switch to STANDBY, and return the JP1 jumper wire. Set the POWER switch to ON again, the update the panel setup as follows:



Connect the CAL. OUT. signal to the INPUT-1 connector.

(12) Adjust R181 so the marker is positioned to the peak of the 50 MHz signal response.

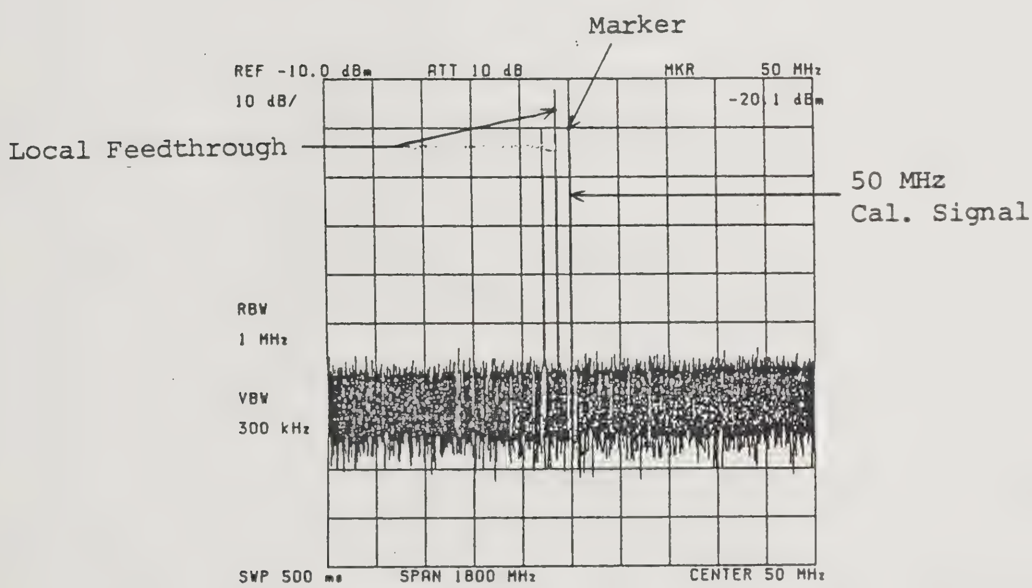


Fig. 11-22 X-axis center adjustment

(13) Set the POWER switch to STANDBY, and return the board to its original slot (without extender board). Reset the POWER switch to ON.

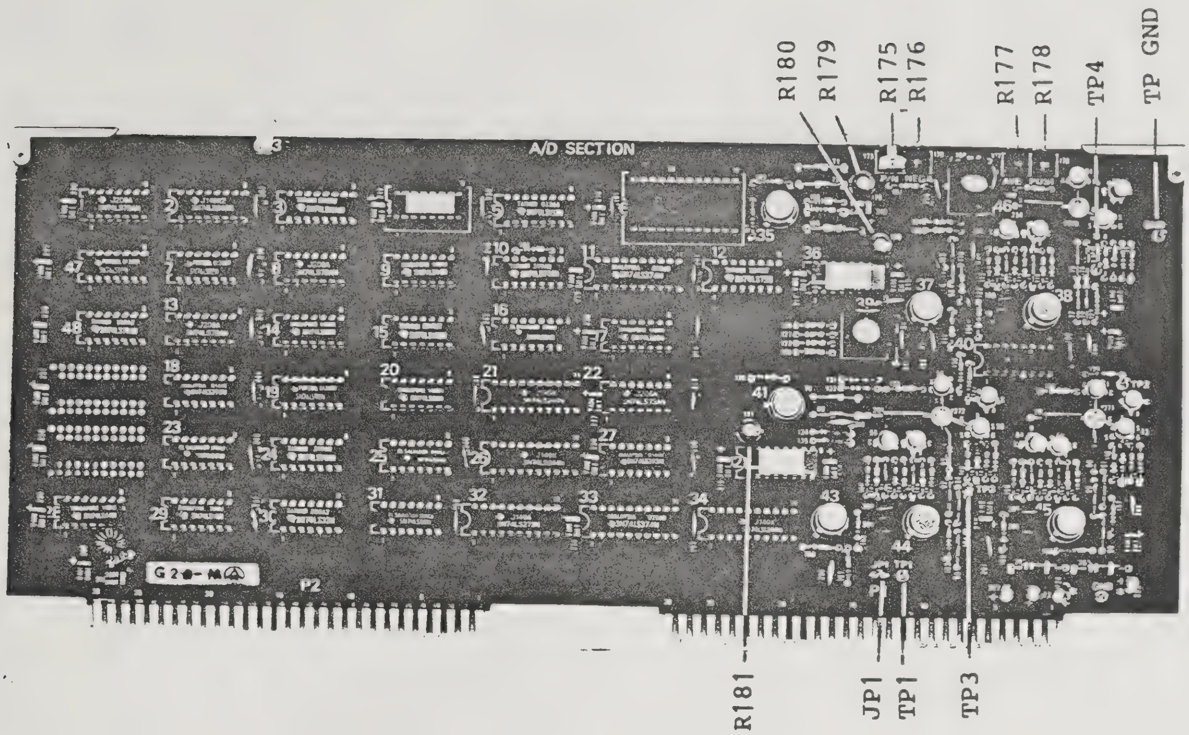


Fig. 11-23 Locations of adjustments and test points on the A-D Converter (BGP-010187) board

11-5-9. Log Amp. Adjustment (Board: BLP-010231) MEP-337
(Circuit Diagram No. 30) (Parts Allocation No. 24)

Instruments required: * Digital voltmeter (four and a half digits)
* Signal generator
* Spectrum analyzer (with tracking generator)
* High-impedance probe
* Attenuator covering 0 to 100 dB in 10-dB steps

(1) Log. amplifier 3.33 MHz tuning

(a) Set the POWER switch to ON and warm up the instrument for at least 10 minutes. Connect the tracking generator output of the second spectrum analyzer to the LOG IN terminal on the LOG AMP board. Set the tracking generator output to -40 dBm. Remove the shield case over from the LOG AMP unit. Using the second spectrum analyzer with a high impedance probe attached to its input, observe the signal appearing on the board across R152 and GND.

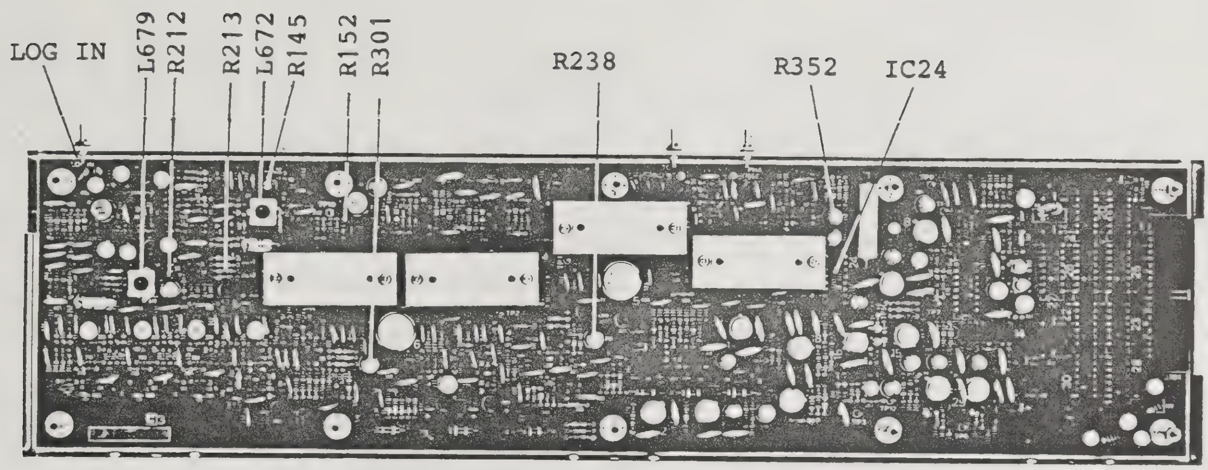


Fig. 11-24 LOG AMP 3.33 MHz tuning

(b) Set resolution bandwidth to 100 kHz. Adjust L672 until the signal response peak on the second spectrum analyzer is 3.333 MHz.

(c) Press $\boxed{}_{\text{RES. BW}}$ $\boxed{\Uparrow}$ to set resolution bandwidth to 300 kHz. Use the observed signal response peak as a reference. Press $\boxed{\Downarrow}$ to reduce resolution bandwidth to 100 kHz, and adjust R145 until the signal response peak comes to the reference level (within ± 0.1 dB).

(d) Set the tracking generator output connected to the LOG IN terminal) to -10 dB. Set resolution bandwidth to 100 kHz. Connect the second spectrum analyzer to R213. Adjust L679 until the peak signal response observed on the second analyzer is positioned at 3.333 MHz.

(e) Press $\boxed{}_{\text{RES. BW}}$ $\boxed{\Uparrow}$ to increase resolution bandwidth to 300 kHz. Then reduce it to 100 kHz, adjusting R212 until the peak level matches the peak level obtained at a 300 kHz resolution bandwidth (within ± 0.1 dB).

(2) LOG AMP gain and offset adjustment

(a) Connect a signal generator output to the LOG IN terminal using an external attenuator. Set the S.G. output to 3.333 MHz in frequency and 0 ±0.1 dBm in level. Check the voltage at pin 3 or 14 of IC 24 (to GND) with a digital voltmeter. Set resolution bandwidth to 100 kHz.

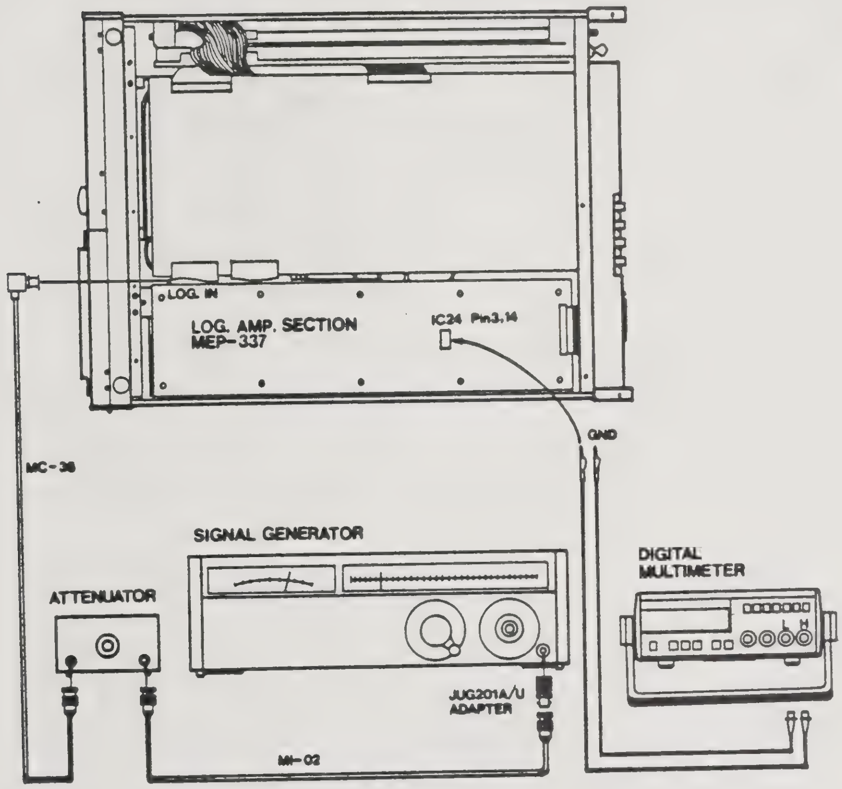


Fig. 11-25 LOG AMP gain adjustment

(b) While changing the external attenuator setting from 60 to 90 dB in 10dB steps, adjust R238 so the LOG AMP OUT voltage (at pin 3 or 4 of IC 24) changes at 0.500 V ±5 mV steps.

(c) While changing the external attenuator setting from 0 to 40 dB in 10dB steps, adjust R301 so the LOG AMP OUT voltage changes at 0.500 V ±5 mV steps.

(d) Set the external attenuator to 0 dB, and adjust R355 until the LOG AMP OUT voltage is 0.000 V ±5 mV.

(e) Set the external attenuator to 60 dB, and adjust R157 until the LOG AMP OUT voltage is 3.000 V ±5 mV. Repeat several times since R355 and R157 affect each other.

(3) Reference level and DC offset adjustment

Press [REF. LEVEL] [1] [0] [0] [Hz −dBm µsec] to minimize the reference level (the actual reference leve should be positioned at -90 dBm). Set the external attenuator to 60 dB, and adjust R335 until the LOG AMP OUT voltage is +1.000 V ±5 mV.

(4) Gain, offset, and step amplifier adjustment in LIN. mode

(a) Press [REF. LEVEL] [0] [kHz +dBm msec] and [SHIFT] [1 (LIN. X1)], and adjust R355 until the LOG AMP OUT voltage is +5.000 V ±5 mV. Then set the external attenuator to 0 dB, and adjust R294 until the voltage is 0.000 V ±5 mV.

(b) Set the external attenuator to 10 dB. Set the analyzer reference level to -50 dBm, and adjust R254 until the voltage is 0.000 V ±10 mV. Refer to the following table when adjusting the step amplifier in the LIN. mode.

Table 11-4 Step amplifier adjustment in LIN mode

AMP. GAIN	REF. LEVEL	External attenuator	Output voltage	Adjustment
10 dB	-50 dBm	10 dB	0.000 V ±10 mV	R254
20 dB	-60 dBm	20 dB	Same as above	R263
30 dB	-70 dBm	30 dB	Same as above	R254, R263
40 dB	-80 dBm	40 dB	Same as above	R272
50 dB	-90 dBm	50 dB	Same as above	R254, R263, R272

(c) Repeat the adjustment steps several times in the amplifier gain range of 10 to 50 dB as R254, R263, and R272 slightly affect each other.

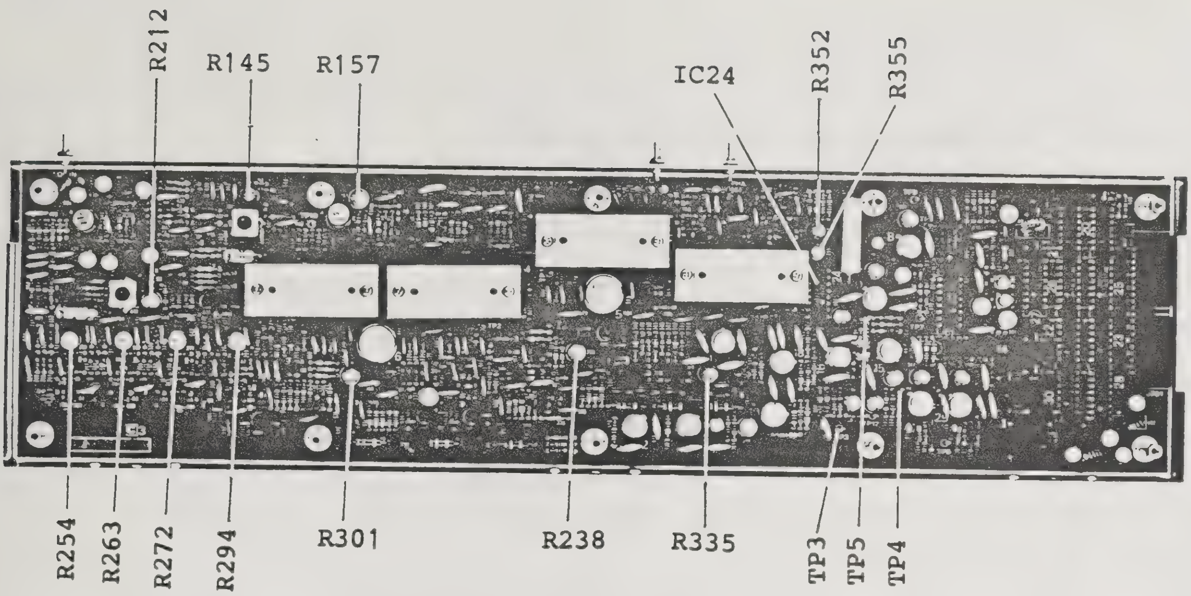


Fig. 11-26 Location of adjustments on the LOG AMP board (BLP-010231)

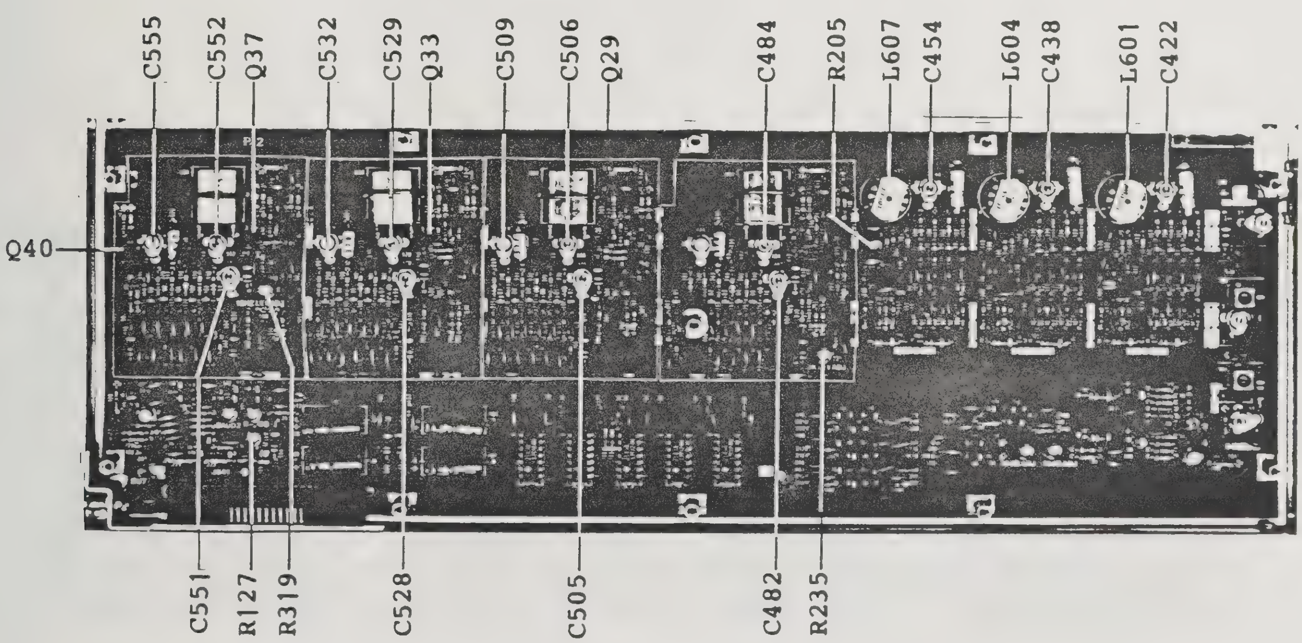


Fig. 11-27 (1) Location of adjustments on the IF1 board (BLP-010229)

11-5-10. IF Filter Adjustment (MEP-338)

(Board and circuit diagram Nos.
IF-1 BLP-010229, Nos. 25, 26
IF-2 BLP-010230, Nos. 27, 28, 29)

Instruments required:
* Spectrum analyzer with tracking generator
* High impedance probe
* Function generator (time base frequency accuracy 10^{-8})
* External attenuator (0-100 dB in 10 dB steps)
(0-10 dB in 1 dB steps)

(1) Set the POWER switch to STANDBY. Remove the IF FILTER block (MEP338) from the chassis. Set the POWER switch to ON again.

(2) Connect the tracking generator output of the external spectrum analyzer to the IF-1 input on the IF block. Set the tracking generator output level at about -20 dBm. Connect the output of the IF-1 block to the input of the external spectrum analyzer.

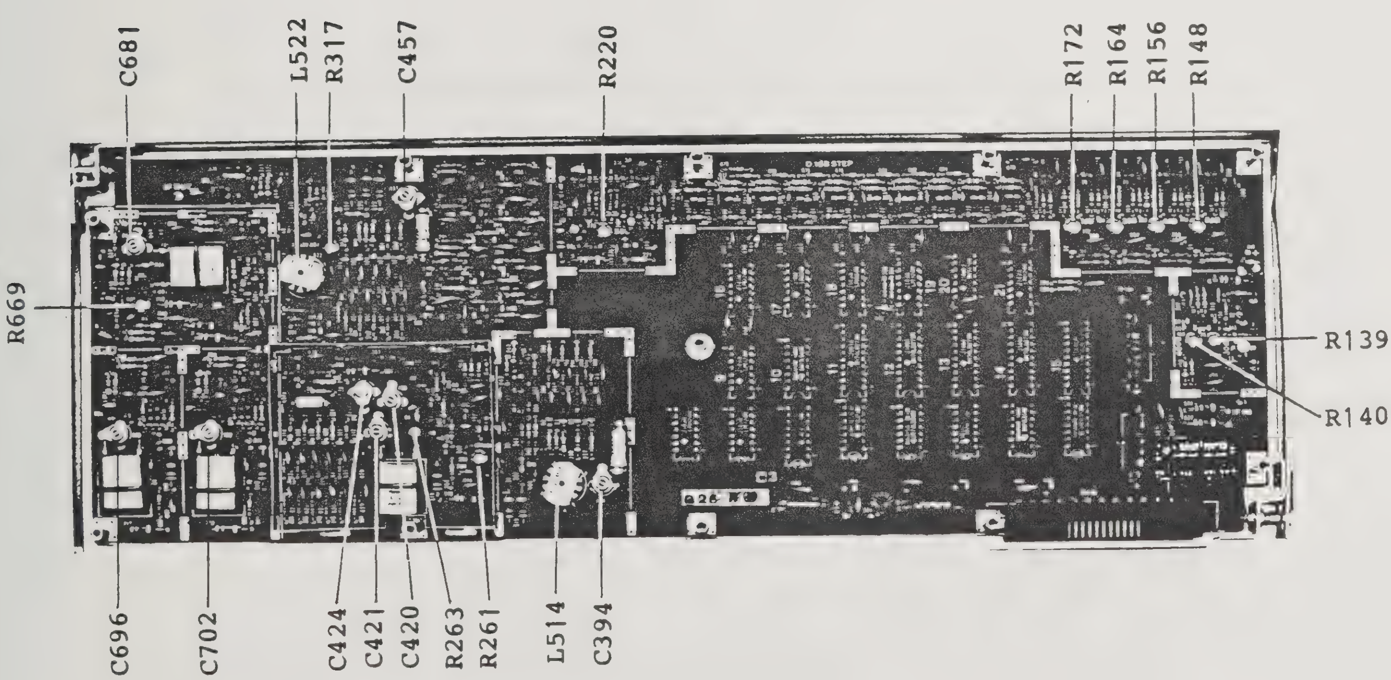


Fig. 11-27 (2) Location of adjustments on the IF2 board (BLP-010230)

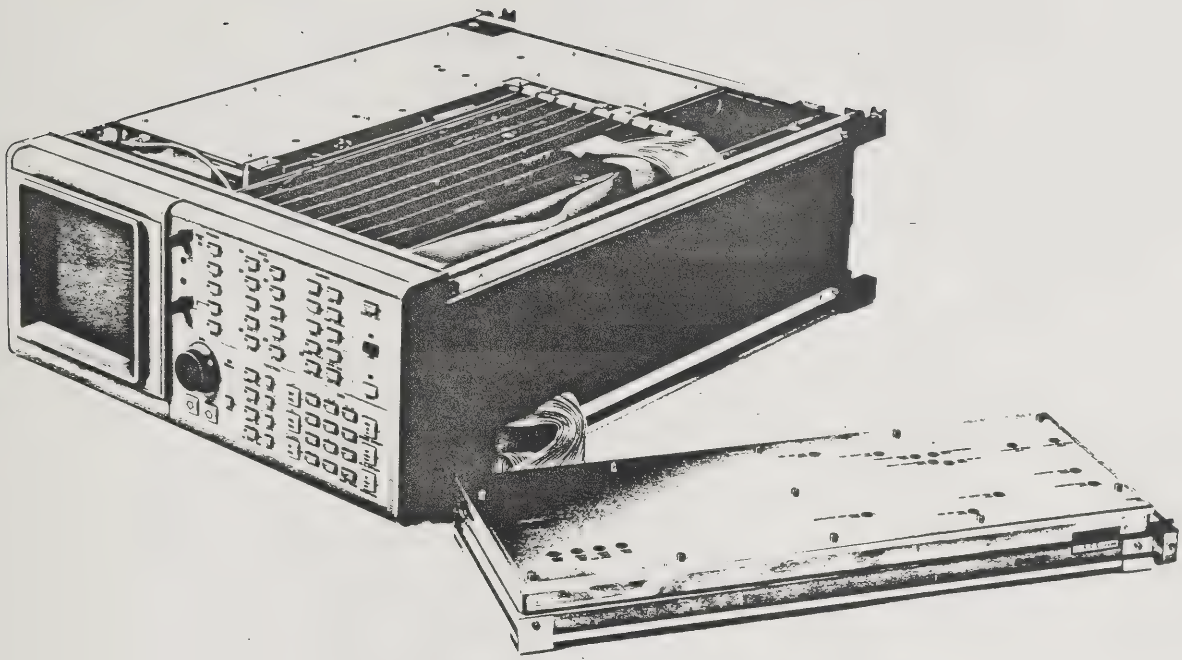


Fig. 11-27 (3) IF section adjustment

(1) IF-1 1 MHz BPF adjustment

Set the reference level to -50 dBm. Unless specified, leave the reference level at this value. Set resolution bandwidth to 1 MHz. Set the center frequency of the second spectrum analyzer to 3.333 MHz and observe the response of the 1 MHz band-pass filter (BPF) in the IF-1 block. Adjust L591, L592, L593 and L594, L595 until the following BPF response is obtained:

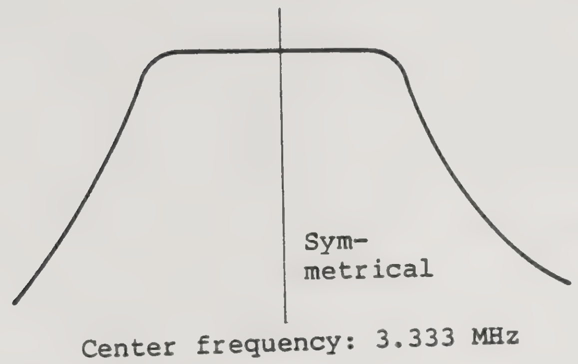


Fig. 11-28 1 MHz BPF response in IF-1 block

(2) IF-1 block LC filter adjustment

(a) Increase the resolution bandwidth to 10 kHz. Connect the function generator output to the IF-1 block input, instead of the tracking generator output. Set up the function generator output for 3.333333 MHz sine wave and -20 dBm output level.

(b) Observe the output of the IF-1 block with the second spectrum analyzer. The center frequency of the analyzer should be set at 3.333 MHz. Adjust L601 and C422 (first filter), L604, and C438 (second filter), and L607 and C454 (third filter) until the output signal level is maximized.

(3) IF-1 quartz filter adjustment

(a) Reduce the resolution bandwidth to 10 Hz. With the function generator set up, observe the output of the IF-1 block using the second spectrum analyzer. Adjust C484, C506, C529, and C552 until the output level is maximized.

(b) Connect the tracking generator output of the second spectrum analyzer to the input of the IF-1 block, instead of the function generator output. Set the T.G. output level to about -20 dBm. Remove the shield case cover from the IF-1 block. Set the resolution bandwidth to 3 kHz.

(c) Using the high-impedance probe attached to the input of the second spectrum analyzer, observe the signal response at the Q29 emitter (input of X632) using the analyzer. Adjust C482 until the signal response observed on the analyzer is centered. Adjust C486 until the frequency at the signal response peak is 3.33333 MHz.

(d) Observe the signal response at the Q33 emitter (input of X633) using the spectrum analyzer. Adjust C505 so the signal response on the screen is centered. Adjust C509 until the frequency at the signal response peak is 3.33333 MHz.

(e) Next, observe the signal response at the Q37 emitter (input of X634) using the analyzer. Adjust C528 for waveform balance and C532 for frequency.

(f) Observe the signal response at the Q40 collector. Adjust C551 for waveform balance and C555 for frequency.

(g) Remount the shield case cover on the IF-1 block.

(4) IF-2 block LC filter adjustment

(a) Connect the output of the IF-1 block to the input of the IF-2 block. Connect the function generator output to the input of the IF-1 block. Set up the function generator output for a sine wave with the frequency of 3.333333 MHz and output level of -20 dBm.

(b) Set the resolution bandwidth to 10 kHz. Observe the output of the IF-2 block with the second spectrum analyzer. The center frequency of the analyzer should be set at 3.333 MHz. Adjust L514 and C394 (first filter) and L522 and C457 (second filter) until the output level is maximized.

(5) IF-2 block crystal filter adjustment

(a) Reduce the resolution bandwidth to 10 Hz. Adjust C421 until the output level is maximized.

(b) Connect the tracking generator output of the second spectrum analyzer to the input of the IF-1 block, instead of the function generator output. Set the T.G. output level at around -20 dBm. Set the resolution bandwidth to 3 kHz.

(c) Observe the output of the IF-2 block with the second spectrum analyzer. Adjust C420 until the filter response is symmetrical. Adjust C424 until the frequency at the signal response peak is 3.33333 MHz.

(6) IF-2 block crystal filter 7 Hz adjustment

(a) Press [SHIFT] [LABEL] [POSIT. PEAK D. / AUTO] p to set the resolution bandwidth to 7 Hz. Apply the function generator output to the input of the IF-1 block. Set up the function generator output for a sine 3.333333 MHz sine wave and -20 dBm output level.

(b) Connect the spectrum analyzer to the output of the IF-2 block, and adjust C702, C696, and C681 until the maximum output signal level is attained.

(c) Mount the shield case cover on the IF-2 block.

(7) IF 10 dB Step Amplifier adjustment

(a) Press [SHIFT] [LABEL] [BACK SPACE] to clear the correction value setup for the Error Correction Routine. Apply the tracking generator output of the second spectrum analyzer to the input to of IF-1 block via external attenuators (with 10 dB and 1 dB steps in series). Set the T.G. output level at around -10 dBm. Connect the spectrum analyzer to the output of the IF-2 block to observe its output signal response.

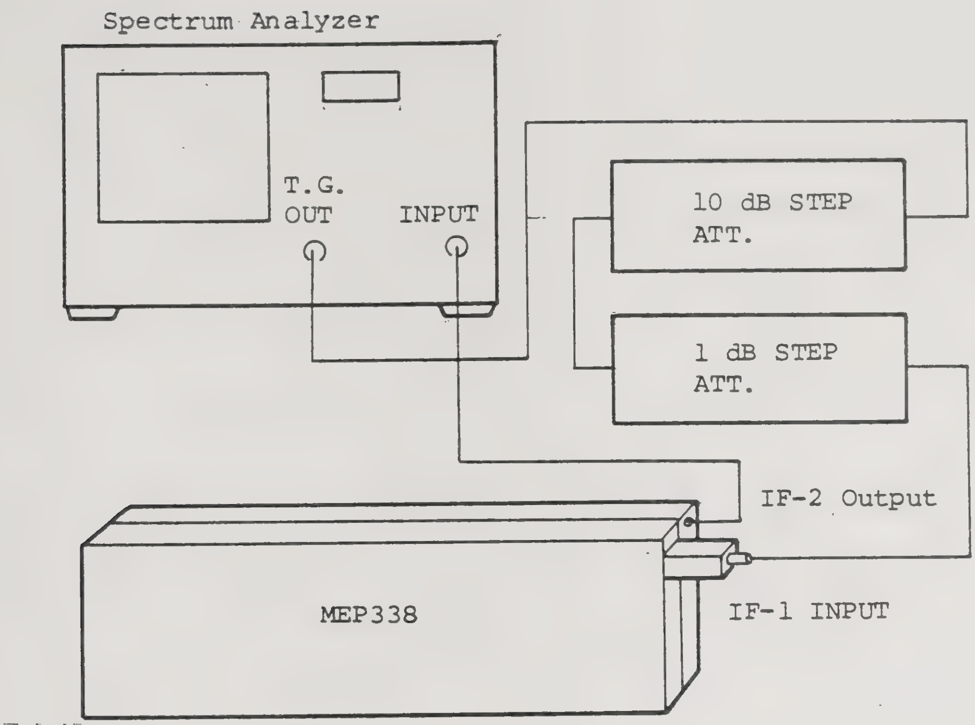
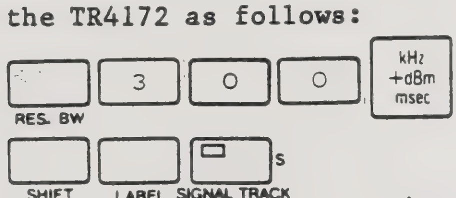


Fig. 11-29 Step amplifier adjustment

(b) Set both attenuators to 0 dB, and update the panel setup for the TR4172 as follows:



(IF step amplifier check 10 dB mode)

(c) Pressing $\boxed{0}$ will select STEP AMP gain of 0 dB, and pressing $\boxed{1}$ will select STEP AMP gain of 10 dB. During this mode, keys $\boxed{0}$ to $\boxed{5}$ select step amplifier gains from 0 dB to 50 dB respectively at 10 dB steps, however, the active function area readout does not change.

(d) Press 0 to set the step amplifier gain to 0 dB, and note the peak level of the observed signal response on the spectrum analyzer. While referring to the table below, adjust each trimmer resistor listed so the peak levels obtained at step amplifier gains of 10 dB 50 dB are within ±0.05 dB with respect to the peak level observed when the amplifier gain was 0 dB.

Table 11-5 IF step amplifier adjustment

IF STEP AMP GAIN	0 dB	10 dB	20 dB	30 dB	40 dB	50 dB
External attenuator	0 dB	10 dB	20 dB	30 dB	40 dB	50 dB
Location of adjustment		IF-1	IF-1	IF-2	IF-2	IF-2
No.		R136	R137	R139	R140	R220

(8) 1 dB step attenuator adjustment

(a) This adjustment should be performed by following the 10 dB step amplifier adjustment. In the IF Step Amp Check 10 dB mode, press 0 to set the step amplifier gain to 0 dB. Then press signal track to set the IF step attenuator to 1 dB. Operation of 0 through 9 will set the 1 dB step attenuator to 0-9 dB at 1 dB steps, respectively.

(b) Set the external attenuator (with 1 dB stepping) to 10 dB. Press 0 to select the 1dB step ATT to 0dB. Note the signal response peak level observed at that time on the analyzer. Referring to the following table, adjust each trimmer resistor listed so the signal response peaks are within ±0.05 dB with respect to the peak level observed when the 1 dB step attenuator was set at 0 dB.

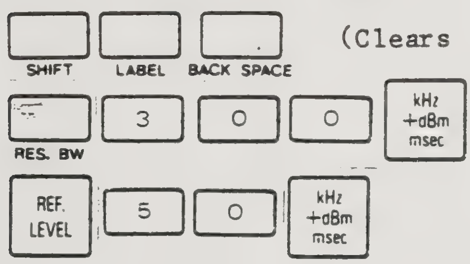
Table 11-6

IF STEP ATT	0 dB	1 dB	2 dB	4 dB	8 dB
External attenuator	10 dB	9 dB	8 dB	6 dB	2 dB
Location of adjustment		IF-2	IF-2	IF-2	IF-2
No.		R172	R164	R156	R148

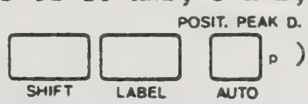
(9) Resolution bandwidth switching level accuracy adjustment

(a) Apply the output of the second spectrum analyzer tracking generator to the input of the IF-2 block, and observe the output of the IF-2 block with the same analyzer. Set the tracking generator output level to about -20 dBm.

(b) Set up the TR4172's panel as follows:



(Clears the error correction data)

(c) Referring to the peak output level obtained at a resolution bandwidth of 300 kHz, adjust R317, R261, R263, and R669 on the IF-2 block so the peak levels obtained at resolution bandwidths of 10 kHz, 3 kHz, 10 Hz, and 7 Hz (set up by operating 

) are within ±0.5 dB with respect to the reference level.

(d) Connect the tracking generator output to the input of the IF-1 block, and observe the output of the IF-1 block with the spectrum analyzer.

(e) Referring to the peak output level obtained at a resolution bandwidth of 300 kHz, adjust R205, R235, and R319 on the IF-1 block so the peak levels obtained at resolution bandwidths of 10 kHz, 3 kHz, and 10 Hz are within ±0.5 dB with respect to the reference level.

(10) Total level adjustment

(a) Apply the output of the second spectrum analyzer's tracking generator to the input of the IF-1 block, and observe the output of the IF-2 block. Connect the output of the IF-1 block to the input of the IF-2 block.

(b) Set up the TR4172's panel as in (9)-(b).
Adjust R127 on the IF-1 block until the gain from the input of the IF-1 through the output of the IF-2 is +5 ±0.1 dB.

(c) Set the POWER switch to STANDBY. Return the IF Filter block to its original slot, then set the POWER switch to ON again.

11-5-11. Phase and G.D. Adjustment (Board No. BLP-010205) MEP-339 (Circuit diagram Nos. 31, 32)

Instrument required: * Digital voltmeter
* Spectrum analyzer with tracking generator
* High-impedance probe

(1) Reference voltage and null adjustment

(a) Remove the shield case cover from the MEP-339. Change jumper connection for J556 to (2)-(3), and adjust R292 until the voltage across TP1 and TP2 is 0.00 V ±0.03 mV.

(b) Change the jumper connection for J556 to (1)-(2), and adjust R295 until the voltage across TP1 and TP2 is 10.000 V ±3 mV.

(c) Adjust R301 until the voltage across TP1 and TP4 is -3.30 V.

(d) Press [PHASE] [MHz dB sec (PHASE OFFSET)], and use the DATA knob to set phase offset to 2000. Press [kHz +dBm msec], then use the DATA knob again to set G.D. offset to 0. Press [kHz +dBm msec] again, and use the DATA knob to set G.D. offset fine to 0. Adjust R297 until the voltage across TP1 and TP6 is 3.000 V ±5 mV.

(e) Change the jumper connection for J555 into (2)-(3), then adjust R307 until the voltage across TP1 and TP5 is 0.00 ±0.03 mV.

(f) Return the jumper connection for J555 to (1)-(2).

(2) 3.33 MHz, 33.3 MHz, and 30 MHz filters adjustment

(a) Set the POWER switch to STANDBY. Disconnect C418 and TP7 on the board (by removing the appropriate side of the C418 lead).

(b) Connect the output of the tracking generator (of the second spectrum analyzer) to the lead of C418 just removed. The ground connection for the tracking generator output should be located as near to C418 as possible. Set the tracking generator output level to around -30 dBm.

(c) Set the POWER switch to ON. Observe the signal response at the emitter of Q56 with the high-impedance probe attached to the input of the spectrum analyzer. Adjust C422 until the filter response is symmetrical at 3.333 MHz.

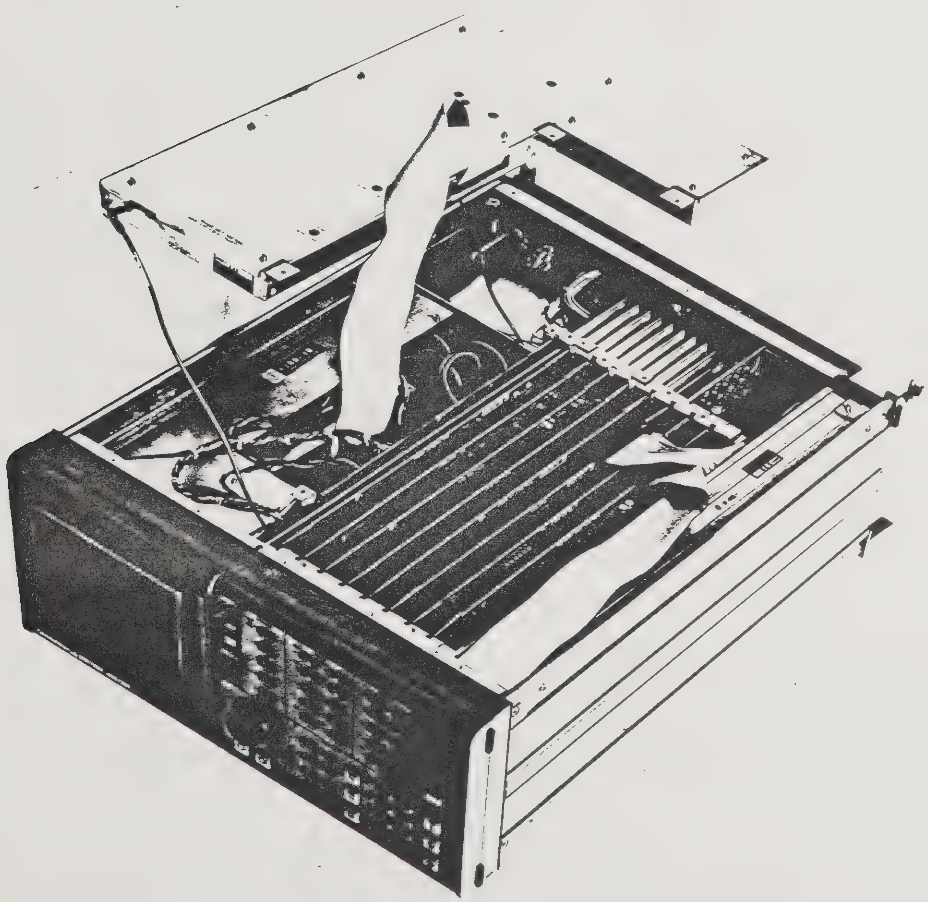


Fig. 11-30 Phase and group delay adjustment (BLP-010205, MEP-339)

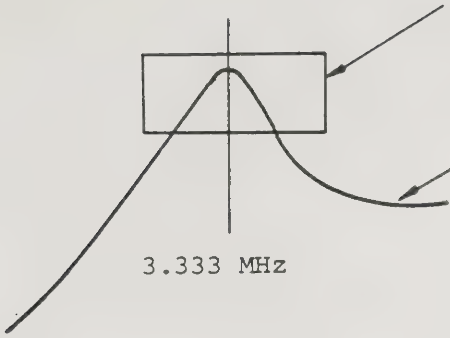


Fig. 11-31 Filter adjustment - 1

(d) Observe the signal at the Q57 collector. Adjust C425 until the filter response is symmetrical at 3.333 MHz.

(e) Set POWER switch to STANDBY. Reconnect the lead of C418 to its original pattern location. Reset the POWER switch to ON.

(f) Apply the output of the tracking generator (contained in the second spectrum analyzer) to J553 (PHASE INPUT). Set the tracking generator output to about 0 dBm. Press PHASE then use the DATA knob to set the phase scale to 40°/div.

(g) Observe the signal waveform at the Q47 emitter. Adjust C386 until the filter response is symmetrical at 3.333 MHz.

(h) Observe the signal waveform at the Q48 collector. Adjust C391 until the filter response is symmetrical.

(i) Reduce the tracking generator output from 0 to -30 dBm. Observed the signal waveform at the Q42 collector. The center frequency for observation is 33.33 MHz.

(j) Adjust C351 until the signal response is symmetrical at 33.33 MHz. Adjust C505 so the level of the signal resolution is reduced with its bandwidth broadened.

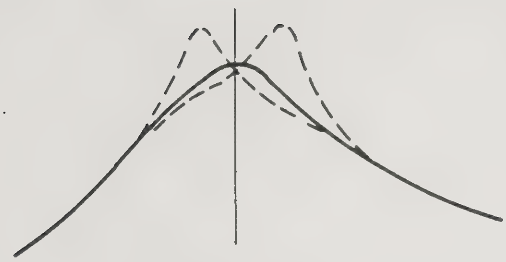


Fig. 11-32 Filter adjustment - 2

(k) Set the POWER switch to STANDBY, and disconnect C369 and C433 on the board (by removing the appropriate side of the C369 lead).

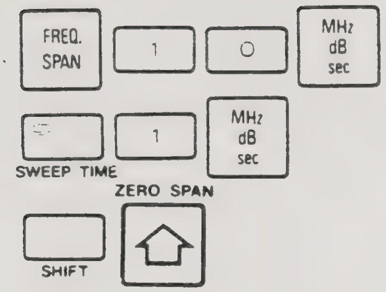
(l) Connect the output of the tracking generator (contained in the second spectrum analyzer) to the lead of C369 just removed. The ground connection for the tracking generator output should be taken as near to C369 as possible. Set the tracking generator output to about -30 dBm.

(m) Set the POWER switch to ON. Connect the spectrum analyzer high impedance probe to the Q44 collector. Adjust C371 until the signal response observed is symmetrical at 30.0 MHz. Adjust C506 so the level of the signal response is reduced, and its bandwidth broadened.

(n) Set the POWER switch to STANDBY, and reconnect the lead of C369 to its original pattern location. Set the POWER switch to ON again.

(3) Output gain and offset adjustment

(a) Connect the TR4172 tracking generator output to its RF input. Press PHASE then use the DATA knob to set the phase scale to 40°/div. Set up the TR4172 panel as follows:



(b) Press PEAK SEARCH, then adjust R273 until the marker readout is within +180 $\pm 0.4^{\circ}$. Press PEAK SEARCH again to confirm the readout.

(c) Press [SHIFT] [NEG. PEAK S.], then adjust R265 until the marker readout is within -180 $\pm 0.4^{\circ}$. Press [SHIFT] [NEG. PEAK S.] again to confirm the readout.

(d) Press [PHASE] [kHz +dBm msec (G. D. OFFSET)], then use the DATA knob to set G.D. offset to 2000. Press [kHz +dBm msec (G. D. OFFSET)] again, then set G.D. offset fine to 0 with the DATA knob.

(e) Adjust R281 so there are 7.5 sawtooth wave forms (2700°) within the horizontal scale span on the TR4172. To shift the signal trace in the horizontal direction, press [MHz dB sec (PHASE OFFSET)], then use the DATA knob.

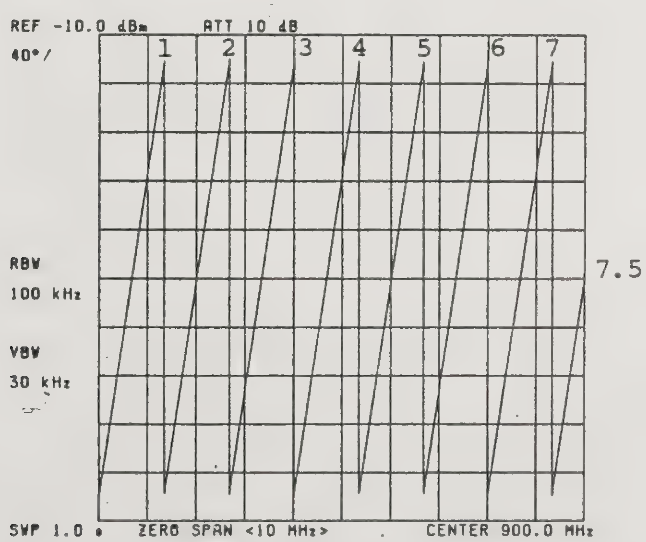


Fig. 11-33 G.D. offset adjustment

(f) Press PHASE, then set the phase scale to 8°/div. with the DATA knob. Press kHz (G.D. Offset), then set G.D. offset to 0 with the DATA knob. Press kHz (G.D. Offset) again, then set G.D. offset fine to 250 with the DATA knob.

(g) Press MHz (Phase Offset), and adjust phase offset with the DATA knob until the signal response trace is centered on the display screen.

(h) Press [PEAK SEARCH], [Δ], [SHIFT] [NEG. PEAK S.], and read the phase value with the delta marker. Adjust R285 until the phase readout is 50.8 ±0.5°.

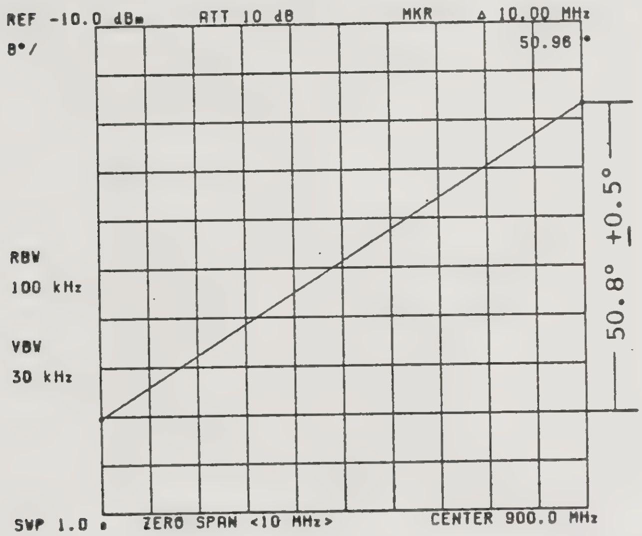


Fig. 11-34 G.D. offset fine adjustment

(i) Proceed with phase offset adjustment. Set up the TR4172 as follows:

PHASE — 40^{o}/div. (with the DATA knob)

kHz +dBm msec (G. D. OFFSET) — G.D. offset to 0 (with the DATA khob)

kHz +dBm msec (G. D. OFFSET) — G.D. offset fine to 0 (with the DATA knob)

MHz dB sec (PHASE OFFSET) — Phase offset to 0 (with the DATA knob)

MARKER

(j) While increasing phase offset from 0 to 4000^{o} with the DATA knob, adjust R283 so the marker readout increases from 0 to 500^{o} as shown below:

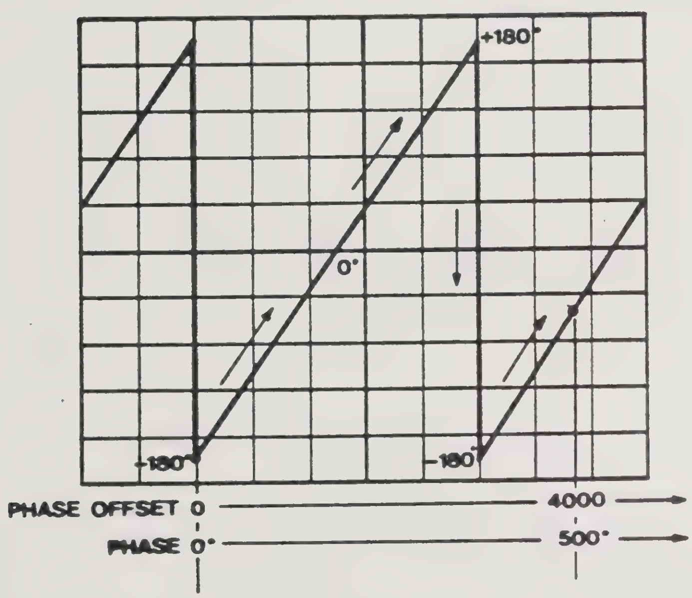


Fig. 11-35 Phase offset adjustment

(k) Remount the shield case cover on the phase board (MEP-339).

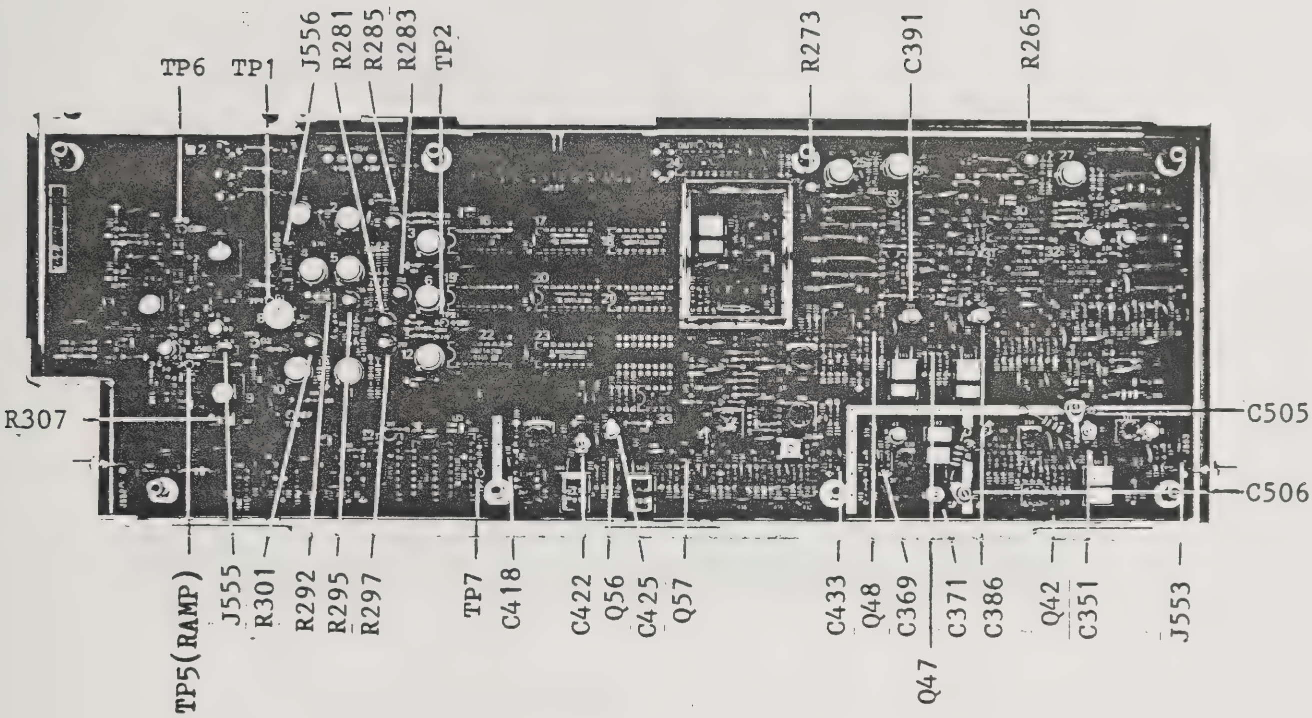


Fig. 11-36 Location of adjustments of PHASE BLOCK (BLP-010205)

11-6. RF SECTION ADJUSTMENT

This paragraph describes TR4172 RF section adjustment.

11-6-1. RF Power Supply Adjustment (Board No. BLF-010370) (Circuit diagram No. 36)

Instrument required: Digital voltmeter

(1) Set the POWER switch to ON, and check the supply voltage at each test point. Figure 11-37 shows the location of the test points and adjustments.

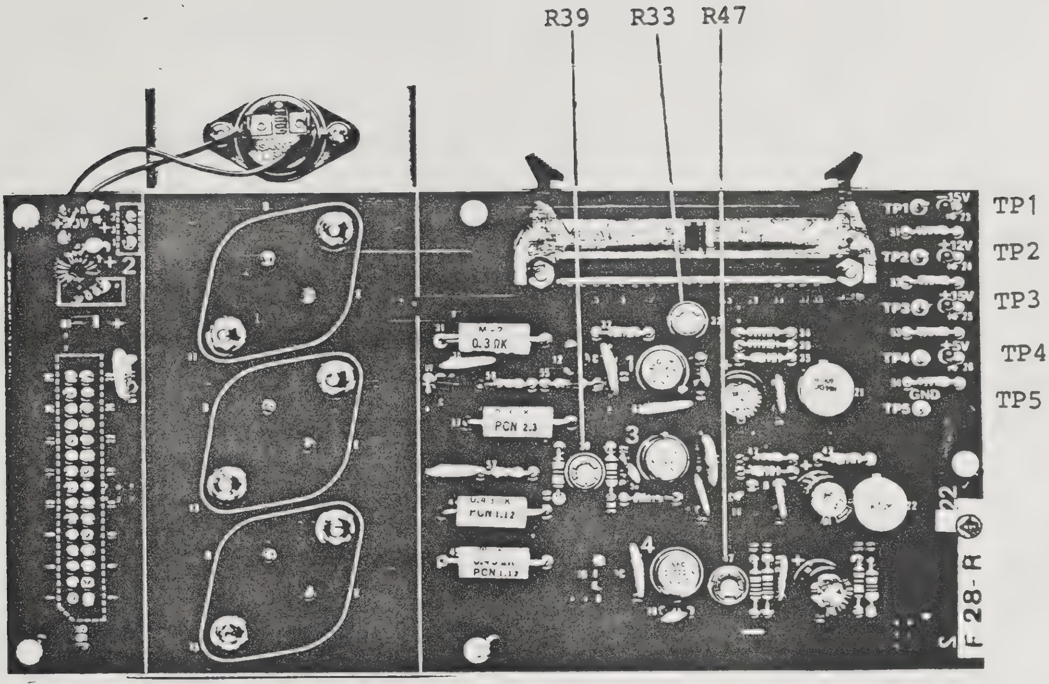


Fig. 11-37 RF Power (BLF-010370) Adjustment

(2) Adjust controls corresponding to each test point in the following order so that the voltages are within the specifications shown in Table 11-7. Always adjust the +15 V at TP-3 first.

Table 11-7 Test points and adjustment

Order	Test point	Voltage	Adjustment
1	TP-3	+15 V ±0.01 V	R39
2	TP-1	-15 V ±0.01 V	R33
	TP-2	+12 V	
3	TP-4	+5 V ±0.01 V	R47
	TP-5	GND	

11-6-2. Tuning and Level Adjustment for 50 MHz standard (CAL) Signal (Board: BLB-010135) MEP-342 (Circuit diagram No. 48)

Instruments required: * Spectrum analyzer
* Power meter

(1) Remove retention screws for the standard block (MEP-342) and arrange it so the block is easily accessible.
Remove the shield case cover from the block.

(2) Change the jumper connection for J141 to (2)-(3). Connect the 50 MHz STD. OUT (J55) to the input to the external spectrum analyzer.

(3) While observing the 50 MHz STD. OUT signal with the external analyzer, adjust L121 through L126 until the maximum peak response is attained.

(4) Change the jumper connection for J141 to (1)-(2), then connect the power meter to the 50 MHz STD OUT. (J55). Adjust R61 until the power meter reading is -20.00 dB ±0.3 dB.

(5) Reinstall the shield case cover on the block, and secure the block (MEP-342) in its original position on the chassis.

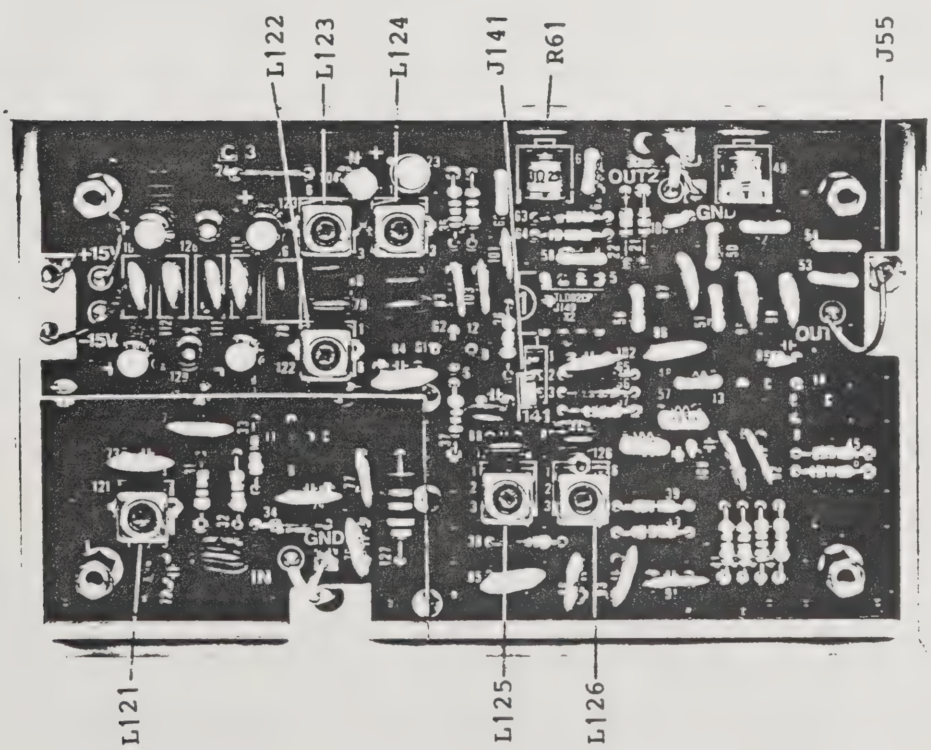
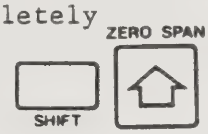


Fig. 11-38 50 MHz STD OUT. adjustment

11-6-3. Offset and Gain Adjustment for ATT. I/O and Level Cal (Board. No. BGN-010220) (Circuit diagram No. 38)

Instrument required: Digital voltmeter

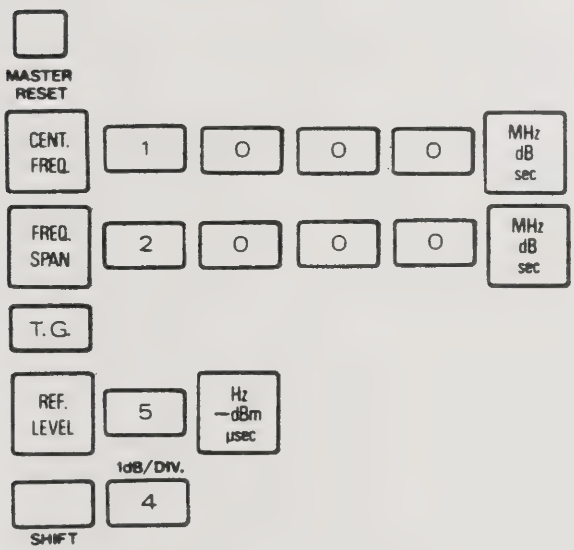
(1) Connect the digital voltmeter across the test point TP RF CAL on the ATT I/O board and the chassis ground.

(2) Turn the CAL. control on the front of the TR4172 completely counterclockwise. Turn R96 on the board completely counterclockwise to minimize the gain. Press 

to select zero frequency span.

(3) Adjust R167 until the voltmeter reading is 2.0 V ±0.1 V.

(4) Connect the TR4172 tracking generator output to its RF input using a cable having a flat frequency response. Set up the TR4172 as follows:



(5) Adjust R96 so the flat portion of the signal response trace is as horizontal as possible.

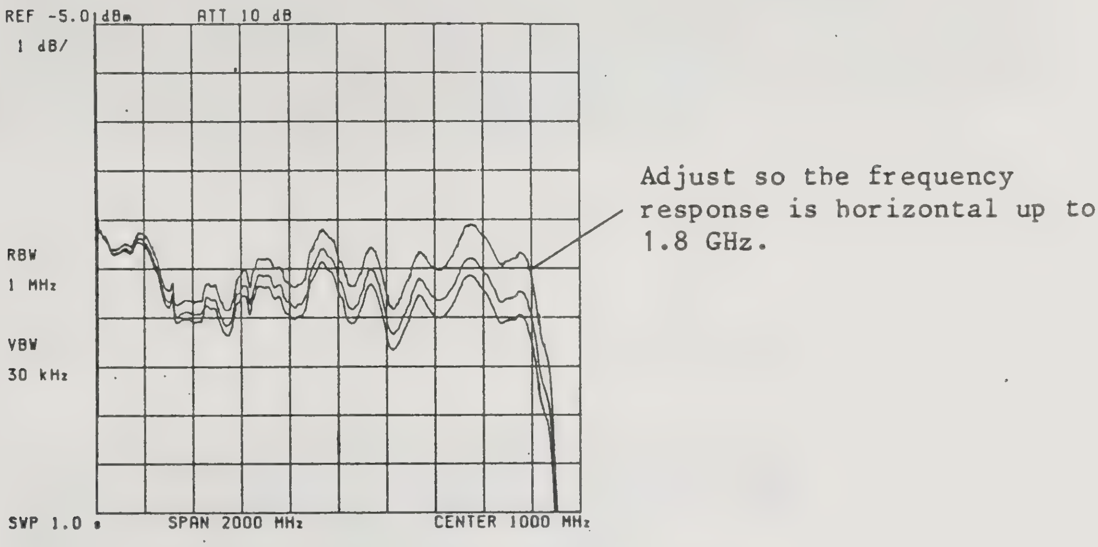


Fig. 11-39 Frequency response correction

11-6-4. YTO Main and FM Tune Adjustment (Board Nos. YIG I/O: BGN-010219, YIG Driver: BLC-010224) (Circuit diagrams Nos. 37, 45)

Instruments required: * Digital voltmeter
* Frequency counter
* Synthesized signal generator
* Marker generator

(1) Reference voltage adjustment for YIG I/O board

(a) Set the POWER switch to STANDBY, and remount the YIG Oscillator I/O board (BGN-010219) in its slot via a 22 pin. extension card. The cables connected to the board connectors should be as they were during adjustment. Set the POWER switch to ON again.

Note: Before changing connections of jumpers, set the POWER swtich to STANDBY.

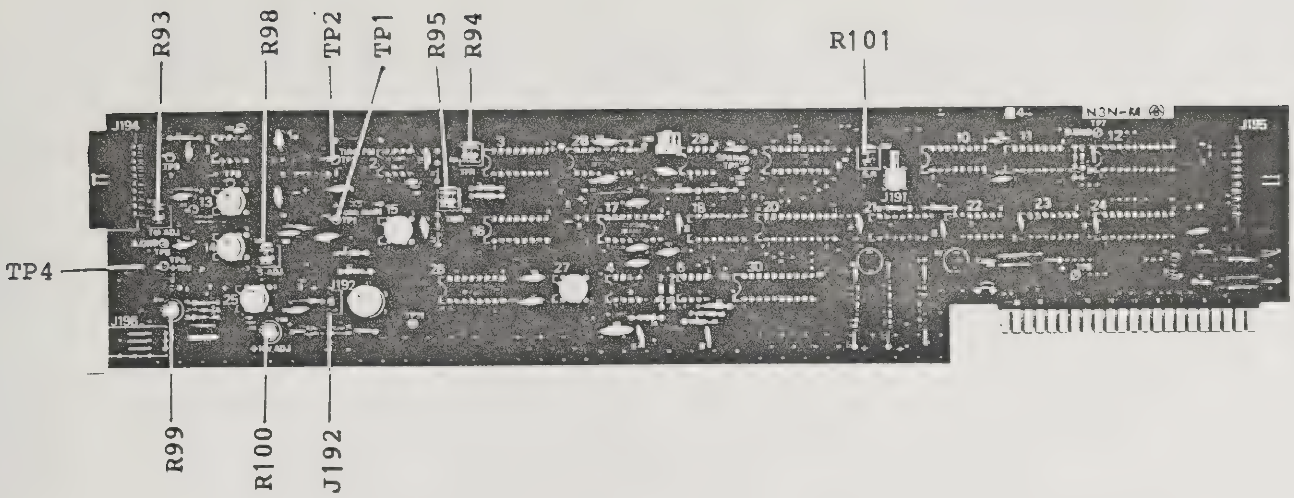


Fig. 11-40 Locations of adjustments on the YIG Oscillator I/O board (BGN-010219)

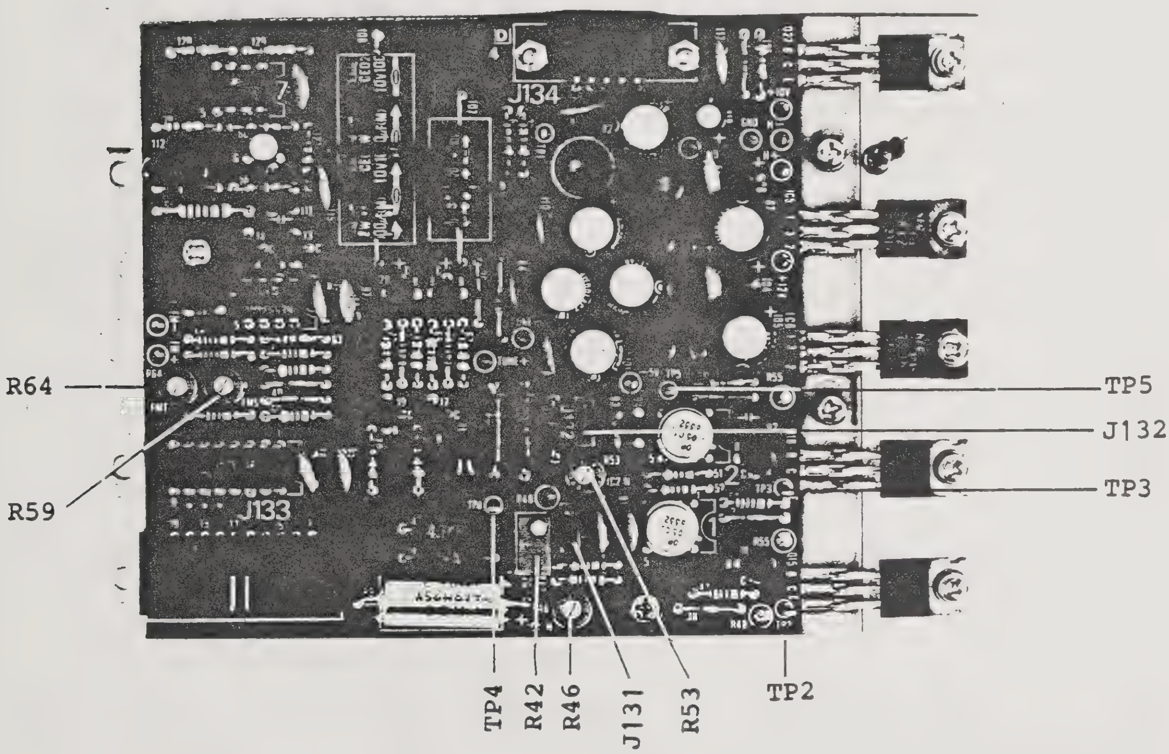


Fig. 11-41 Locations of adjustments on the YIG Oscillator Driver board (BLC-010224)

(b) Change the jumper connection for J192 (on the YIG Oscillator I/O board) to (2)-(3). Adjust R99 on the same board until the voltage across TP-6 (GND) and TP-4 is 0.00 V ±0.03 mV.

(c) Change the jumper connection for J192 into (1)-(2). Adjust R100 until the voltage across TP-6 (GND) and TP-4 is 10.000 V ±3 mV.

(2) Offset null adjustment for YIG Driver board

(a) Change the jumper connection for J131 (on the YIG Oscillator Driver board) into (2)-(3). Adjust R46 on the same board until the voltage across TP-4 (GND) and TP-2 is 0.00 V ±0.03 mV.

(b) Change the jumper connection for J132 (on the YIG Oscillator Driver board) to (2)-(3). Adjust R53 on the same board until the voltage across TP-5 (GND) and TP-3 is 0.00 V ±0.03 mV.

(c) Return the jumper connections for J131 and J132 to (1)-(2).

(3) YTO Main Tune adjustment

(a) Prepare TR4172 as follows:

[MASTER RESET]

[SHIFT] [ZERO SPAN ⇧]

[SHIFT] [LABEL] [Hz −dBm µsec] [INT. A] [1] [0] [0] [0] [Hz −dBm µsec]

The step Main is set to 1000.

(b) Adjust R95 on the YIG Oscillator I/O board until the voltage across TP-1 and TP-6 (GND) on the same board is -5.000 V ±3 mV.

(c) Check the YTO frequency with a frequency counter. Disconnect cable from the output of the 3.9 GHz LPF and connect the frequency counter to the output of the 3.9 GHz LPF section (MEP-351).

(d) Press [SHIFT] [LABEL] [Hz −dBm µsec] [LINE B] [2] [0] [0] [0] [Hz −dBm µsec] to set the step FM to 2000. Press [SHIFT] [LABEL] [Hz −dBm µsec] [INT. A] [1] [0] [0] [Hz −dBm µsec] to set Step Main to 100.

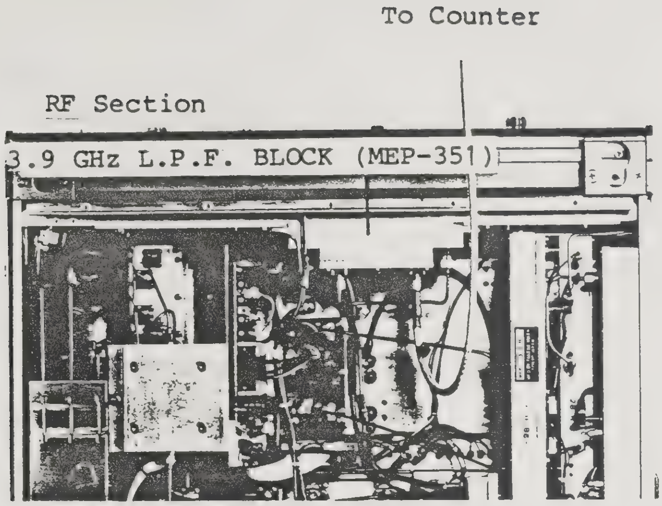


Fig. 11-42 YTO frequency measurement

(e) Adjust R42 on the YIG Oscillator Driver board until the counter reading is 2046 MHz ±300 kHz.

(f) Press [1] [9] [0] [0] [Hz −dBm μsec] to set Step Main to 1900. Adjust R93 on the YIG Oscillator I/O board until the counter reading is 3846 MHz ±300 kHz.

(g) Repeat above steps several times as R42 (on the driver board) and R93 (on the I/O board) affect each other.

(h) When completing the YTO Main Tune adjustment, disconnect the frequency counter from the output of the 3.9 GHz LPF section (MEP-351) and connect the output to the original cable.

(4) YTO Main Span accuracy adjustment

(a) Set up the TR4172 as follows:

[MASTER RESET]

[CENT. FREQ.] [5] [0] [0] [MHz dB sec]

[FREQ. SPAN] [1] [0] [0] [0] [MHz dB sec]

(b) Set up the synthesized signal generator output for 500 MHz and a level of -10 dB, and couple it to the input of the TR4172.

(c) Center R98 on the YIG Oscillator I/O board.

(d) Adjust R101 on the YIG Oscillator I/O board so the signal responses are positioned to the leftmost, center, and rightmost graticules on the screen as shown in the following figure.
When R101 is adjusted, however, R86 and R92 on the 3rd Local I/O board also require adjustment. (See page 11-58)

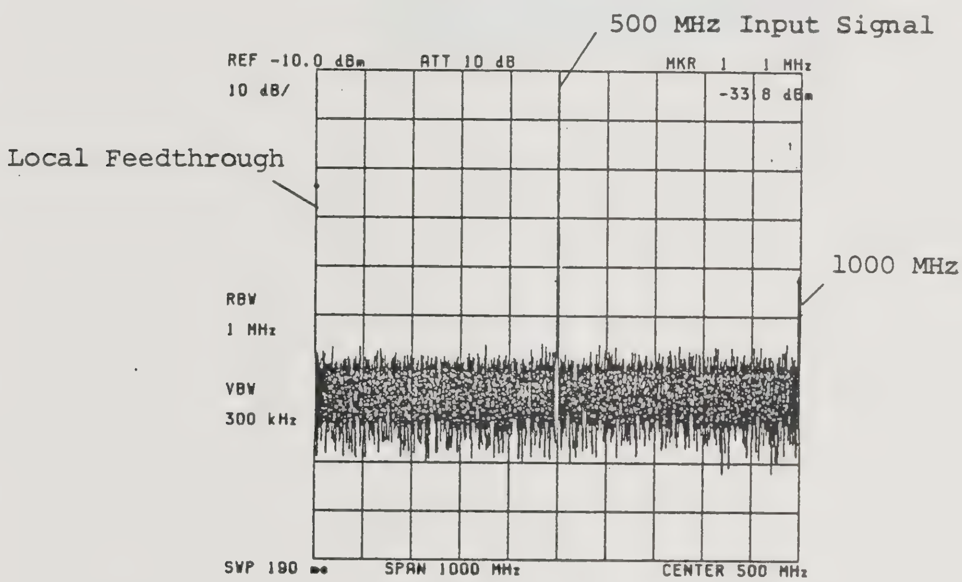
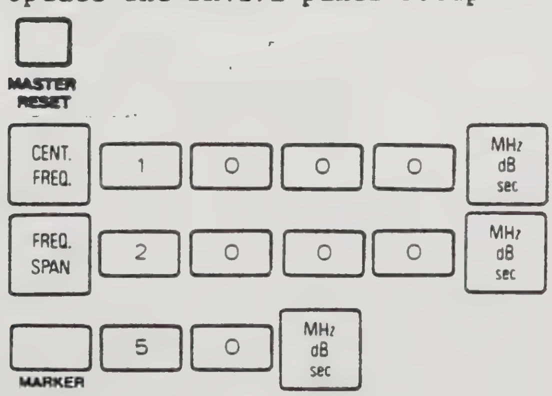


Fig. 11-43 YTO main span adjustment (1)

(e) Apply the 50 MHz STD. (CAL.) signal to the TR4172 input. Update the TR4172 panel setup as follows:



(f) Adjust R98 on the YIG Oscillator I/O board until the marker is positioned at the peak of the 50 MHz CAL. signal response.

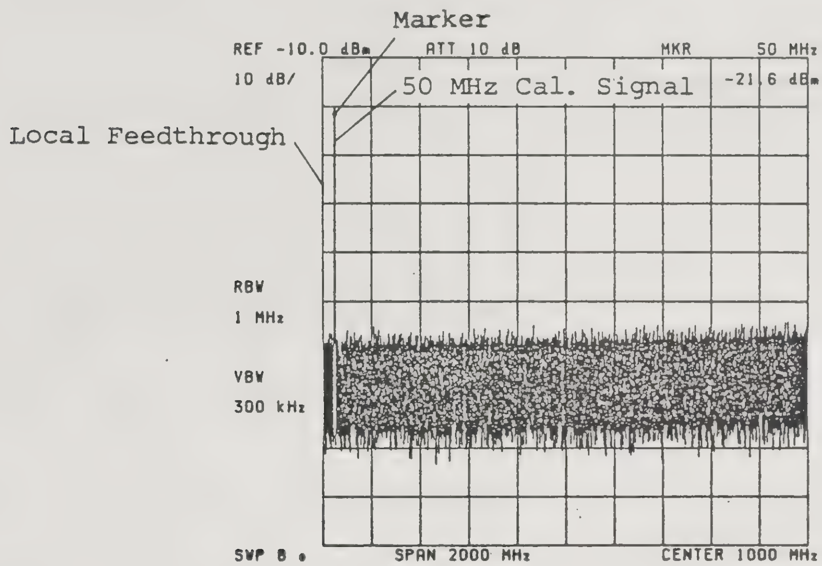
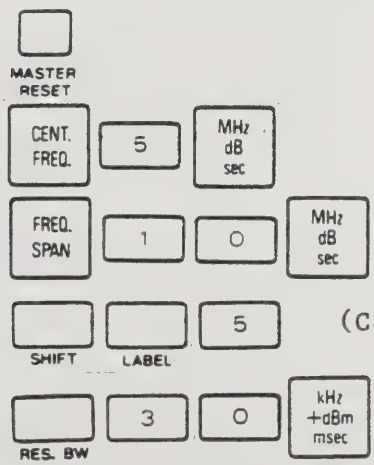


Fig. 11-44 YTO main span adjustment (2)

(5) YTO FM tune and span accuracy adjustment

(a) Connect the output of a marker generator to the TR4172 input. Setup the marker generator output for a 1 MHz comb signal with fullpower around 0 dBm. Update the TR4172 panel setup as follows:



(b) Adjust R59 on the YIG Oscillator Driver board until each response of the 1 MHz comb signal is positioned at each vertical graticule on the screen. (See Figure 11-44.) The signal response on the screen can be shifted horizontally by pressing CENT. FREQ. key and then using the DATA knob.

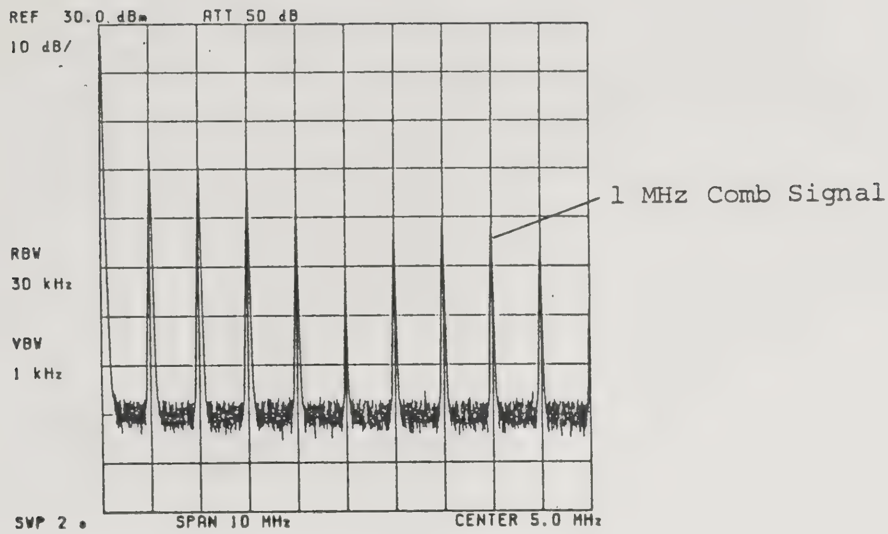


Fig. 11-45 YTO FM tune adjustment (1)

(c) Disconnect the TR4172 marker generator, then set center frequency to 0 MHz. Press [SHIFT] [LABEL] [Hz/−dBm/μsec] [LINE] B [2] [0] [0] [0] [Hz/−dBm/μsec] to set Step FM to 2000.

(d) Adjust R94 on the YIG I/O board until the voltage across TP-2 and TP-6 (GND) on the same board is -5.000 V ±3 mV.

(e) Adjust Step 3RDA (by pressing [SHIFT] [LABEL] [Hz/−dBm/μsec] [EXT.] C and using the DATA knob) or Step Main (by pressing [SHIFT] [LABEL] [Hz/−dBm/μsec] [INT.] A and using the DATA knob) to center the local feedthrough.

(f) Press [SHIFT] [LABEL] [Hz/−dBm/μsec] [LINE] B [0] [Hz/−dBm/μsec], and while changing the Step FM setting to 0, 2000, and 4000 by operating [0] [Hz/−dBm/μsec], [2] [0] [0] [0] [Hz/−dBm/μsec] then [4] [0] [0] [0] [Hz/−dBm/μsec], adjust R64 on the YIG Oscillator Driver board so the local feedthrough is positioned to the rightmost, center, and leftmost graticule on the screen, respectively.

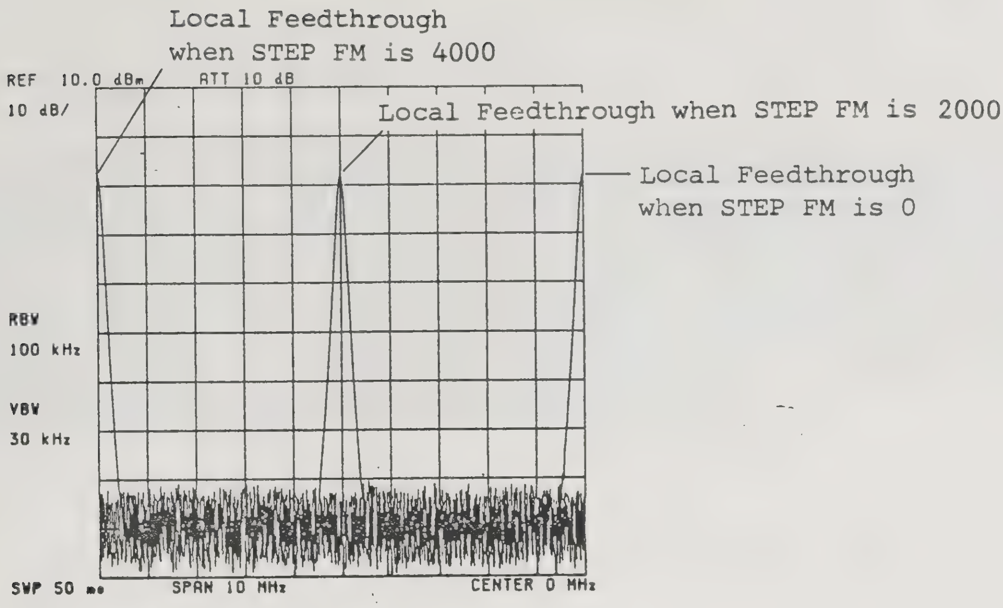


Fig. 11-46 YTO FM tune adjustment (2)

(g) Set the POWER switch to STANDBY. Remount the YIG Oscillator I/O board in its original slot (without the extender board). Set the POWER switch to ON again.

11-6-5. 3rd Local I/O Adjustment (Board No. BGN-010221) (Circuit diagram No. 39)

Instruments required: * Digital voltmeter
* Marker generator

(1) Reference voltage adjustment and adjustment of Tune D-A, B, C

(a) Set the POWER switch to STANDBY, then remount the 3rd Local I/O board (BGN-010221) in its slot via an extension card (22 pins). The cables connected to the on-board connectors should be left as they are. Set the POWER switch to ON again.

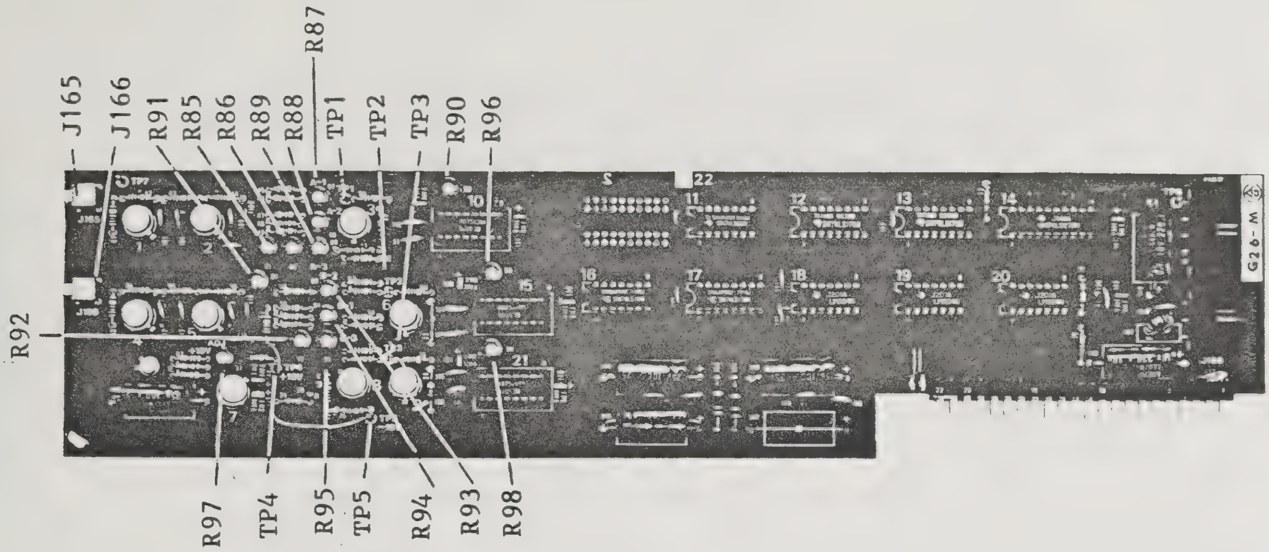
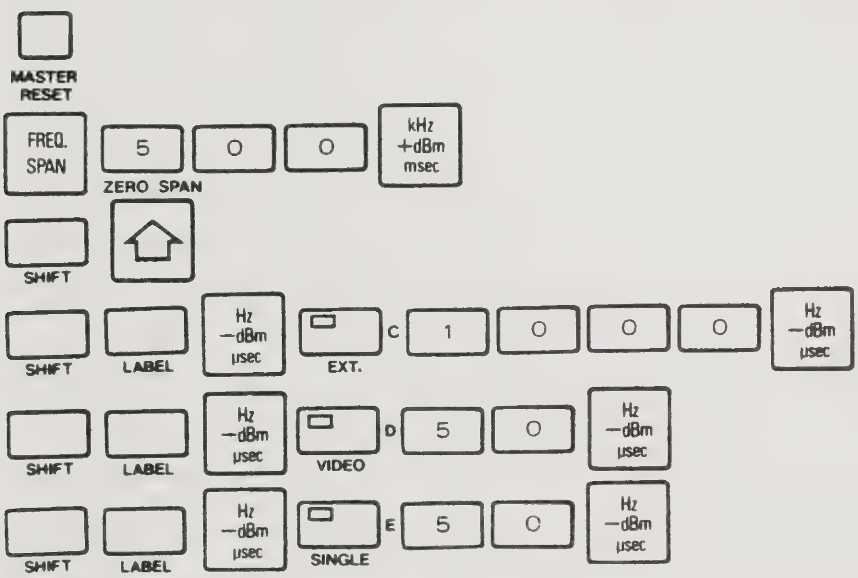


Fig. 11-47 3rd local I/O adjustment (BGN-010221)

(b) Connect the digital voltmeter across Tp-4 and TP-7 (GND). Adjust R97 until the voltmeter reads 10.000 V ±3 mV.

(c) Set up the TR4172 as follows:



(d) Check the voltage across TP-7 (GND) and TP-1, TP-2, and TP-3. Adjust R90, R96, and R98 until the voltage at each test point is 5.000 V ±3 mV.

(2) Gain and offset adjustment for Sweep A (20 MHz VCO) Tune

(a) While the TR4172 is set up as shown in paragraph (1)-(c), change Step 3RDA to 0, then 2000 (by operating [SHIFT] [LABEL] [Hz −dBm μsec] [EXT.] c , then using the DATA knob). Adjust R87 so the output voltage change at J165 is within ±4.000 V when Step 3RDA is changed from 0 to 2000.

(b) Set Step 3RDA to 1000 (by pressing SHIFT LABEL Hz −dBm µsec EXT. C, then using the DATA knob). Change Step 3RDB into 0, then 100 (by pressing SHIFT LABEL Hz −dBm µsec VIDEO D, then using the DATA knob). Adjust R88 so the output voltage change at J165 is within ±20 mV when Step 3RDB is changed from 0 to 100.

(c) Set Step 3RDB to 50 (by pressing SHIFT LABEL Hz −dBm µsec VIDEO D, then using the DATA knob). Change Step 3RDC into 0 and 100 (by pressing SHIFT LABEL Hz −dBm µsec SINGLE E, then using the DATA knob). Adjust R89 so the output voltage change at J165 is within ±2 mV when Step 3RDC is changed from 0 to 100.

(d) Set Step 3RDC to 50 (by pressing SHIFT LABEL Hz −dBm µsec SINGLE E, then using the DATA knob). At this time, Steps 3RDB and 3RDA are set at 50 and 1000 respectively. Adjust R85 until the output voltage at J165 is 5.000 V ±5 mV.

(3) Gain and offset adjustment for Sweep B (2 MHz VCO) Tune

(a) Set frequency span to 50 kHz.

(b) Set Step 3RDA to 500, then 1500. Adjust R94 so the output voltage change at J166 is within ±4.000 V.

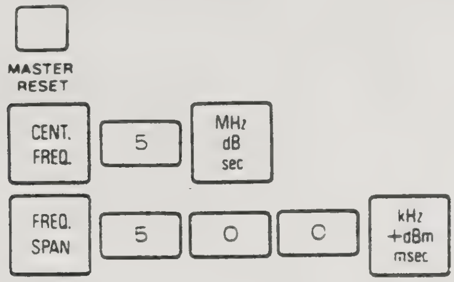
(c) Set Step 3RDA to 1000. Set Step 3RDB to 0 then to 100. Adjust R93 so the output voltage change at J166 is within ±40 mV when Step 3RDB is changed from 0 to 100.

(d) Set Step 3RDB to 50. Set Step 3RDC to 0, then to 100. Adjust R95 so the output voltage change at J166 is within ±4 mV.

(e) Set Step 3RDC to 50. Step 3RDB and 3RDA are set at 50 and 1000 respectively. Adjust R91 until the output voltage at J166 is 5.000 V ±5 mV.

(4) Sweep A and B span accuracy adjustment

(a) Set up the TR4172 as follows:



(b) Connect marker generator output to the TR4172 input. Set the marker generator output to 50 kHz comb signal of full power about 0 dBm.

(c) Adjust R86 so the 50 kHz comb signal responses are aligned to each vertical graticule on the screen as shown below.

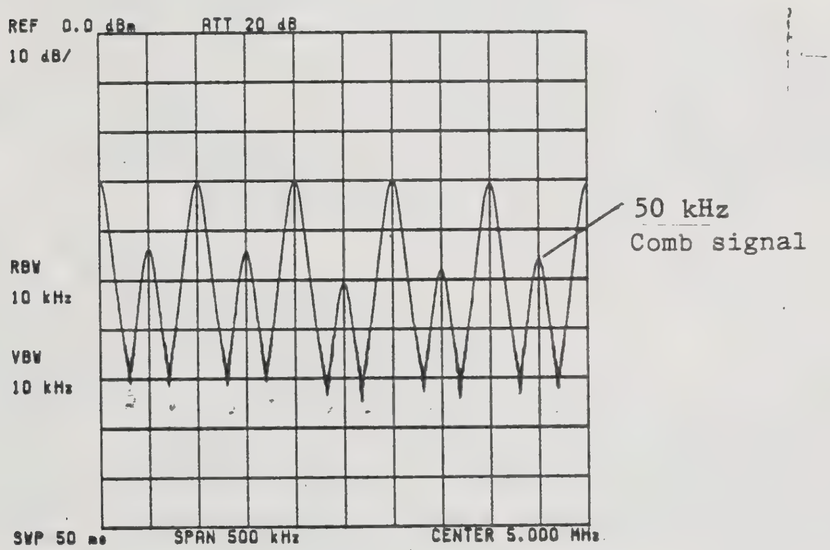


Fig. 11-48 Span accuracy adjustment

(d) Set frequency span to 50 kHz. Set the marker generator output to 5 kHz comb signal.

(e) Adjust R92 so the 5 kHz comb signal responses are aligned to each vertical graticule on the screen.

(f) Set the POWER switch to STANDBY. Return the third Local I/O board into its original slot, then reset the POWER switch to ON.

11-6-6. Counter Adjustment (Board No. BLJ-010131) MEP-349
(Circuit diagram No. 74)

Instruments required: * Digital voltmeter
* Function generator

(1) -1.8 V power supply adjustment

(a) Set the POWER switch to STANDBY, and remove the counter section (MEP-349) from the chassis. Use extension cables to establish the original electrical connections between the counter section and the analyzer mainframe (see Figure 11-49).

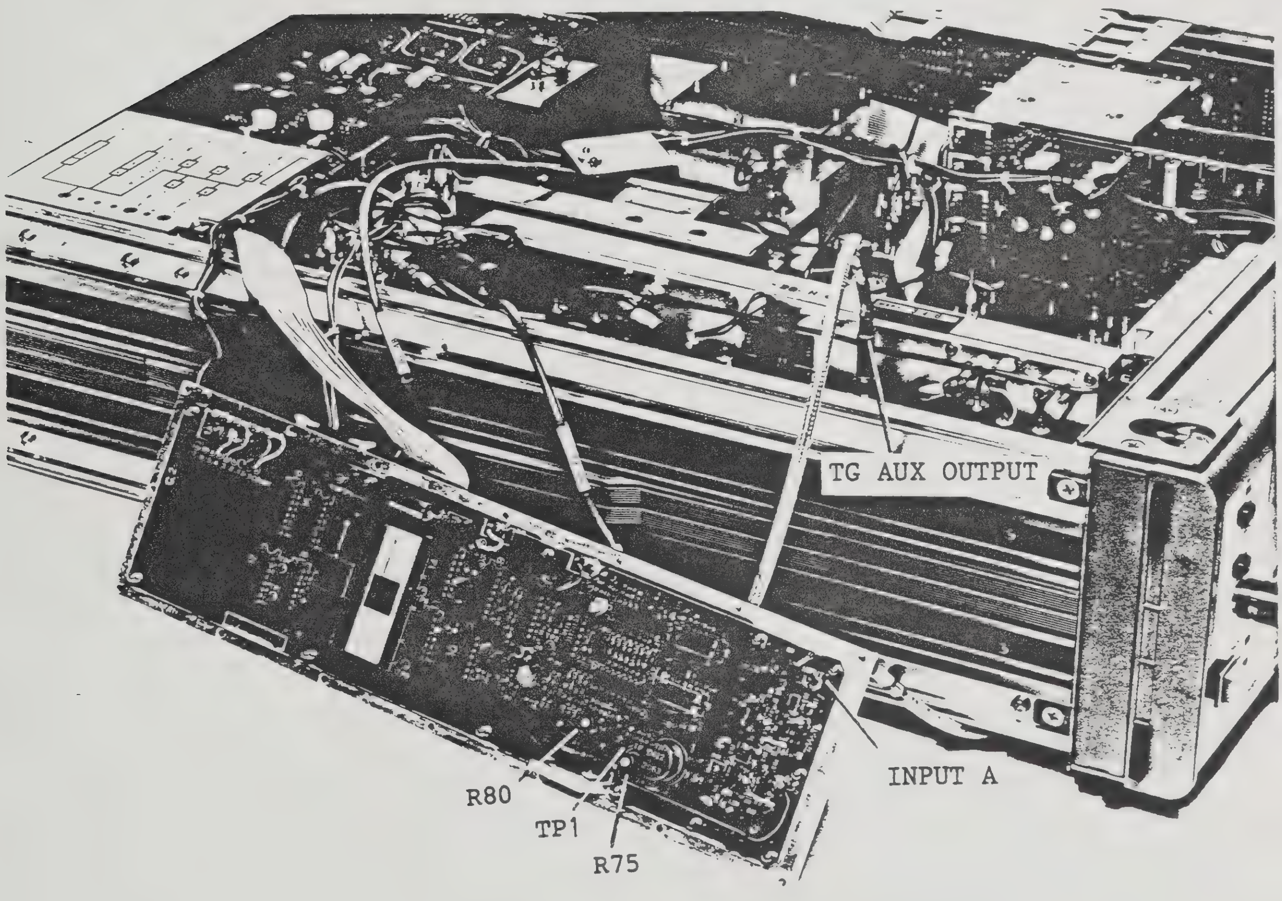
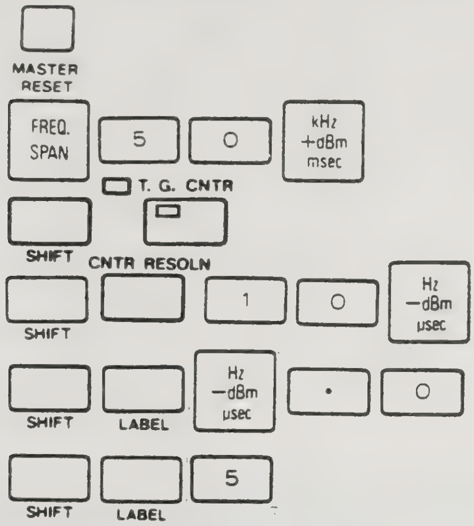


Fig. 11-49 Counter adjustment (MEP-349)

(b) Set the POWER switch to ON. Connect the digital voltmeter to TP-1 on the board, and adjust R80 until the voltage at TP-1 is -1.8 $\pm$0.01 V.

(2) Schmitt trigger sensitivity adjustment

(a) Set up the TR4172 as follows:



(b) Disconnect the cable between the counter input A and TG AUX, then apply the function generator output to the counter input A. Set up the function generator output for a 100 kHz sine wave and -20 dBm output level.

(c) Press 

to count the input signal frequency to the counter. While gradually reducing the function generator output level adjust R75 until the maximum counter sensitivity (at which the counter readout does not flicker) is obtained.

(e) Set the POWER switch to STANDBY. Return the Counter section into its original position in the chassis, then reset the POWER switch to ON.

11-6-7. RF Section Adjustment (Board No. BLP-010133) MEP-345

(Circuit diagram No. 53)

Instruments required: * External spectrum analyzer
* High impedance probe

(1) Second local OSC (1840 MHz) adjustment

(a) Using the external spectrum analyzer, observe the signal response at J20 (second local output of 1840 MHz for TG). Turning C237 will change the oscillation frequency and peak level of the second local OSC output as shown below. Set C237 to the point where the oscillator output level is 1 dB below its peak.

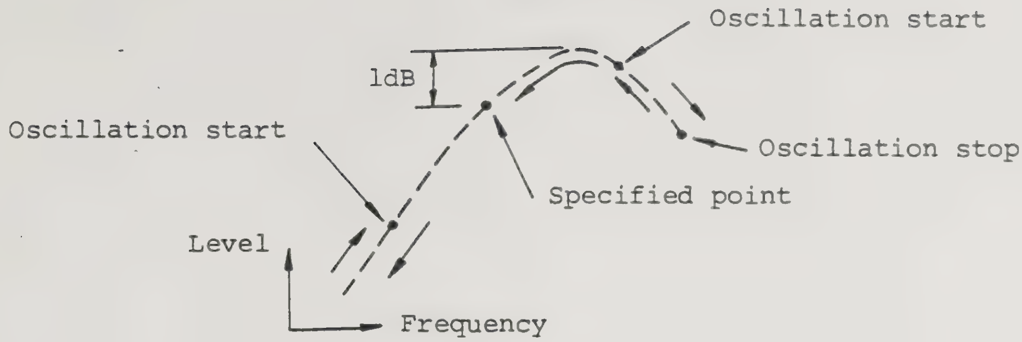


Fig. 11-50 Second local OSC adjustment

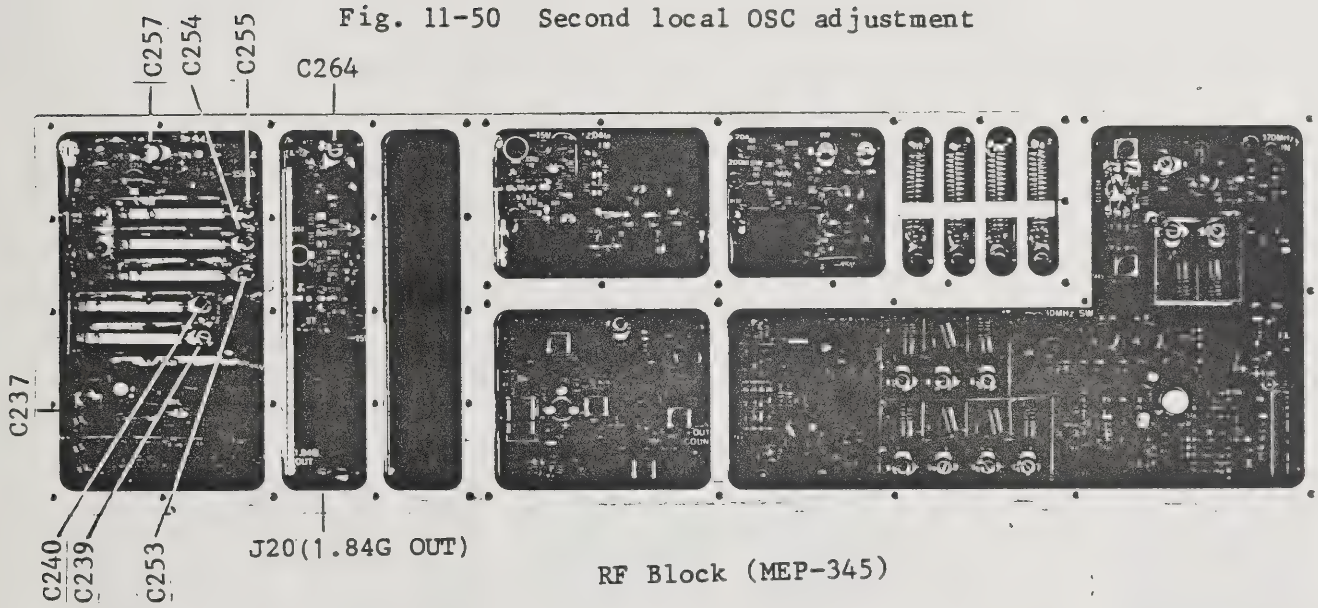


Fig. 11-51 Location of adjustment and connectors on RF block (MEP-345) -1

(b) Adjust C239, C240, C253, C254, C255, C257, and C264 several times until the maximum output level at 1840 MHz is attained.

(c) Adjustment of step (b) will slightly affect the adjustment of step (a). Adjust C239 again so the oscillation level is positioned to 1 dB below the peak oscillation level.

(d) Restore the original connection to J20.

(2) Fourth local OSC (33.33 MHz) adjustment

(a) Using the external spectrum analyzer, observe the signal response at J23 (fourth local OSC output of 33.33 MHz, approximately 0 dBm for TG). Adjusting L430 will change the oscillation frequency and peak level. Set L430 to the point where the oscillation level is 0.5 dB below the peak level.

(b) Adjust L432 until the maximum output level is attained.

(c) Using the external spectrum analyzer, observe the signal response at J24 (fourth local OSC output of 33.33 MHz, approximately -10 dBm for counter). Adjust L433 until the maximum output level is attained.

(d) Remove the shield case cover from the fourth local block in the RF Section (MEP-345). Using the external spectrum analyzer with a high impedance prove attached, observe the signal response at the Q25 collector. Adjust C375 until the maximum observed signal level is attached.

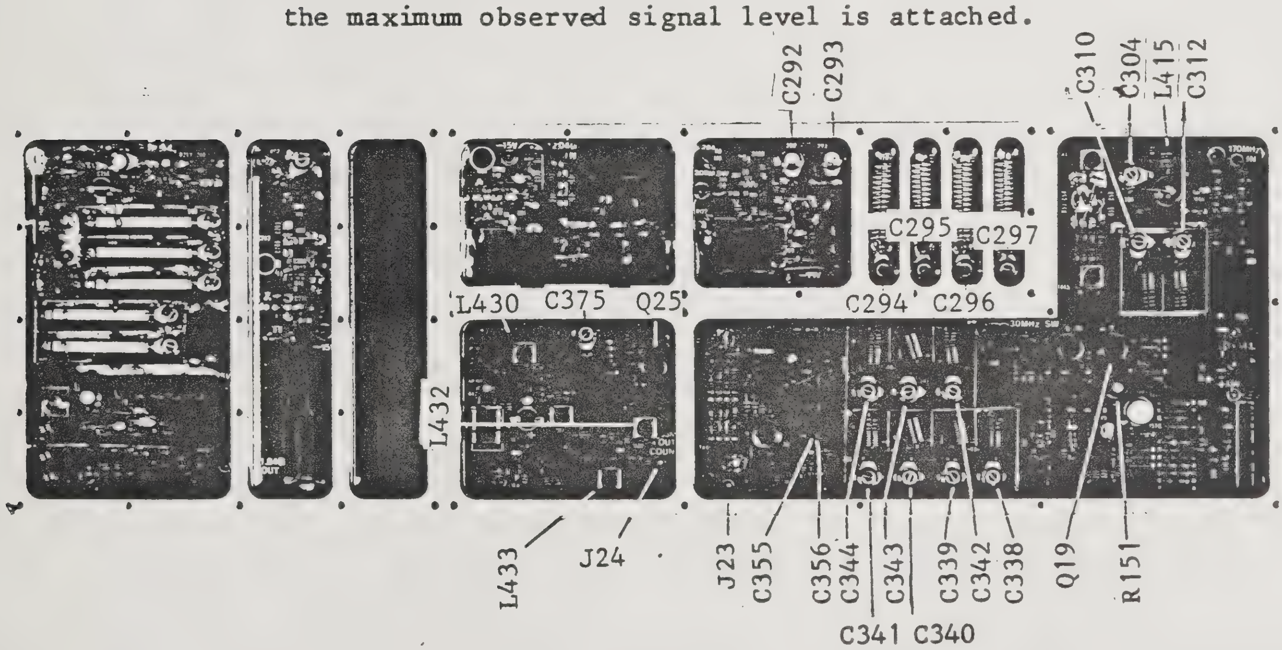


Fig. 11-52 Location of adjustment and connectors on RF block (MEP-345) -2

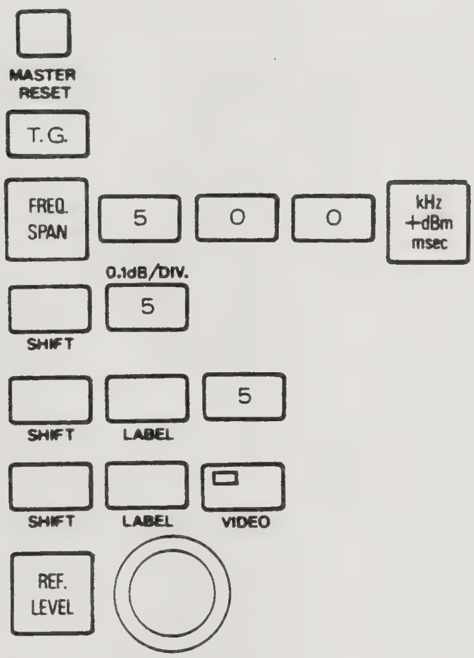
(e) Restore the original connections for J23 and J24.

(3) Third local amplifier (176.3 MHz) adjustment

Using the external spectrum analyzer with the high impedance probe, observe the signal response at the L415 center tap. Adjust C304 until the maximum observed signal level (at approximately 176 MHz) is attained.

(4) Second IF B.P.F. (206 MHz) adjustment

(a) Fine tune level deviation is adjusted by adjusting this filter. Set up the TR4172 as follows:
Connect the TRACKING GENERATOR OUTPUT to INPUT-1, then press as follows:



(b) Adjust C292, C293, C294, C295, C296, and C297 so the ripple is less than 0.3 dBp-p, being careful to keep the symmetry of the signal response and its level as high as possible (see the following figure).

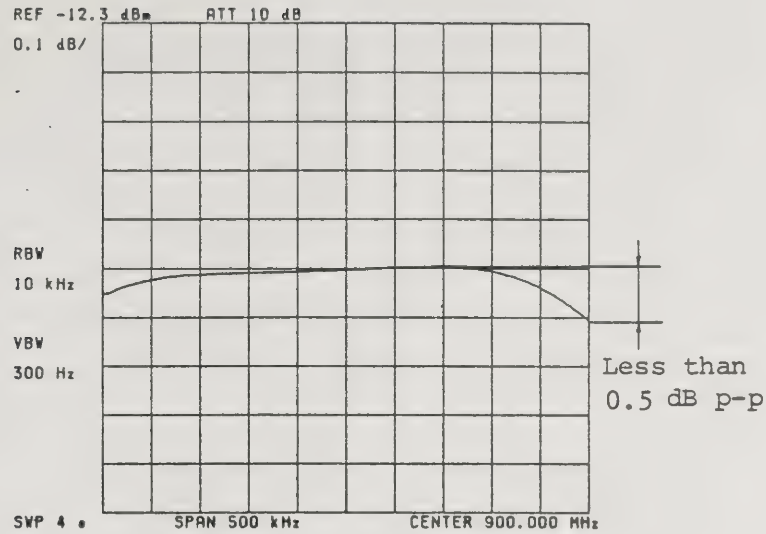
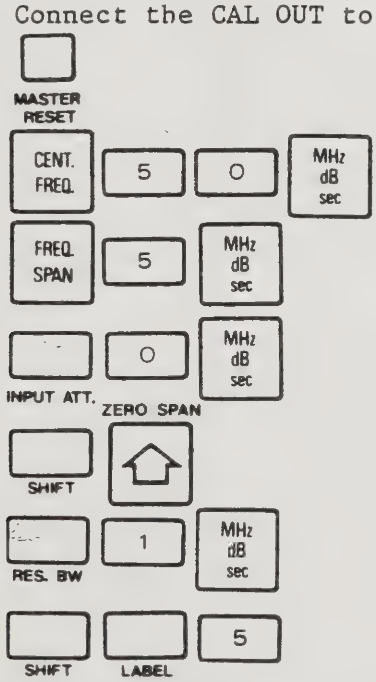


Fig. 11-53 2nd IF BPF adjustment

(5) Third IF B.P.F. (30.0 MHz) adjustment

(a) Set up the TR4172 as follows:

Connect the CAL OUT to INPUT-1.



(b) Using the external spectrum analyzer with the high impedance probe, observe the signal response at the Q19 collector on the board. Set the center frequency of the external spectrum analyzer to 30.00 MHz.

(c) Press [SHIFT] [LABEL] [Hz −dBm µsec] [LINE] B, then change the Step FM setting with the DATA knob. Adjust C310 and C312 so the observed 30 MHz B.P.F. response (two stages) is centered around 30.00 MHz and its maximum level is attained. (See Figure 11-54.) A slight ripple within the pass bandwidth may be ignored.

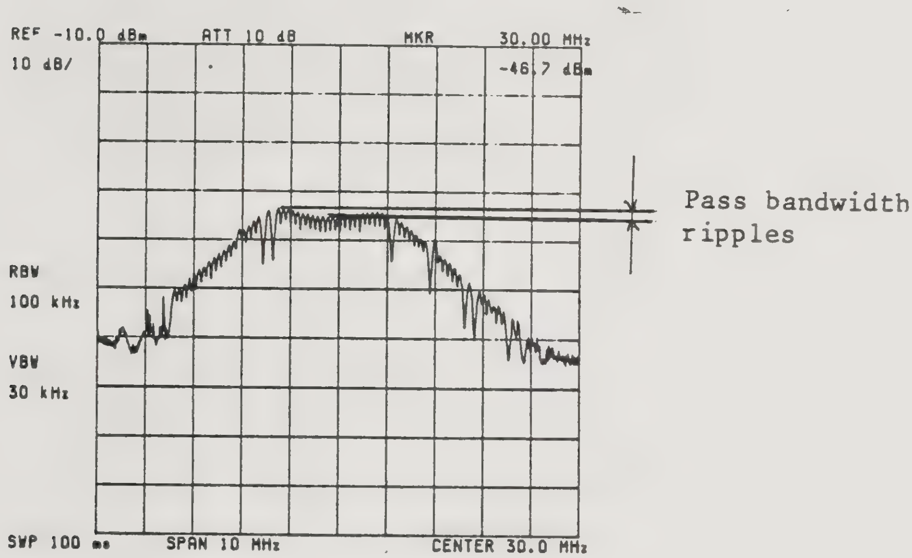


Fig. 11-54 30 MHz B.P.F. (two stages) adjustment

(d) Using the external spectrum analyzer with the high impedance probe, observe the signal response at the connection between C355 and C356. Press [SHIFT] [LABEL] [Hz −dBm µsec] [LINE] B, then use the DATA knob to change the Step FM setting. Adjust C342, C343, and C344 so the observed 30 MHz (three stage) B.P.F. response has a 1 MHz 0.5 dB bandwidth and a maximum level of about 30.00 MHz is attained. (See Figure 11-55.) Step FM will change in 2 kHz steps. If a smaller frequency stepping is desired, press [SHIFT] [LABEL] [Hz −dBm µsec] [EXT.] C.

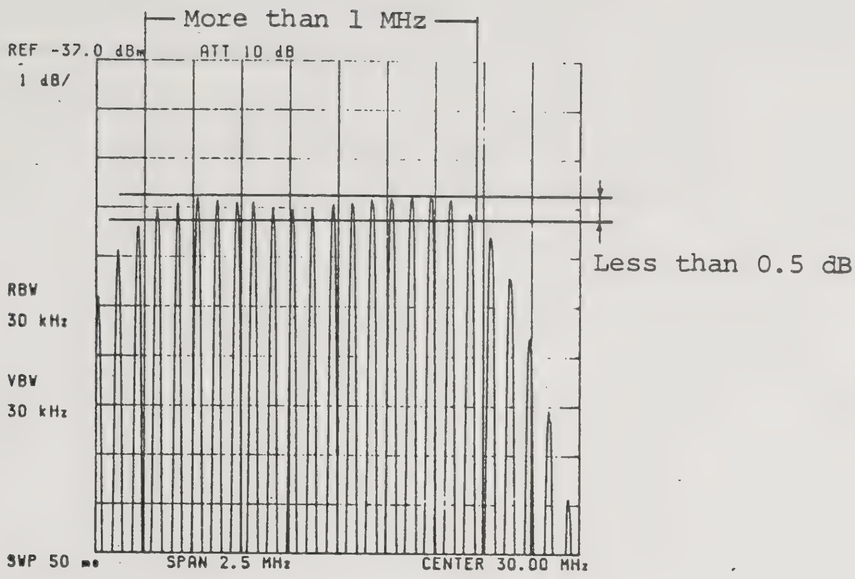


Fig. 11-55 30 MHz (three stage) B.P.F. adjustment

(e) Press [RES. BW] [3] [0] [0] [kHz +dBm msec] to change resolution bandwidth to 300 kHz. As in step (4), adjust C338, C339, C340, and C341 so the filter response has a 0.5 dB bandwidth greater than 300 kHz and its maximum level is about 30.00 MHz.

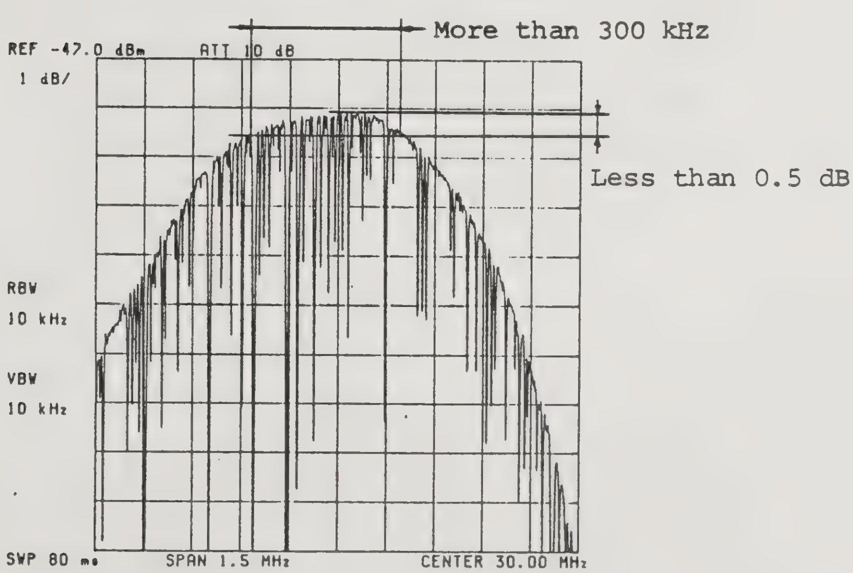
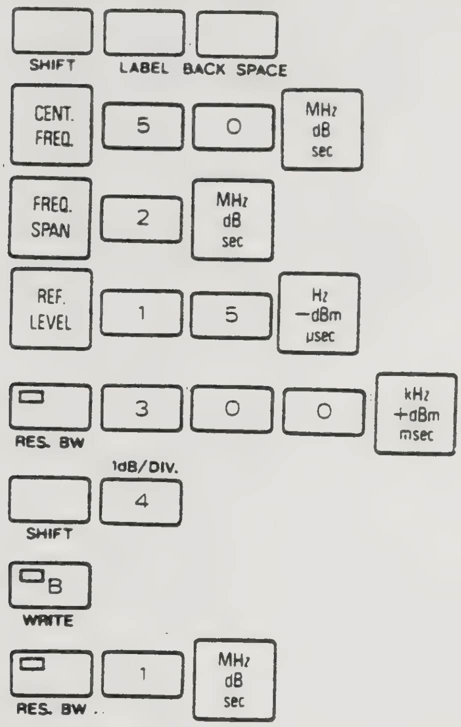


Fig. 11-56 30 MHz B.P.F. adjustment (four stages)

(f) Remount the shield case cover removed in paragraph 2.

(6) Resolution bandwidth 1 MHz, and 300 kHz level deviation adjustment

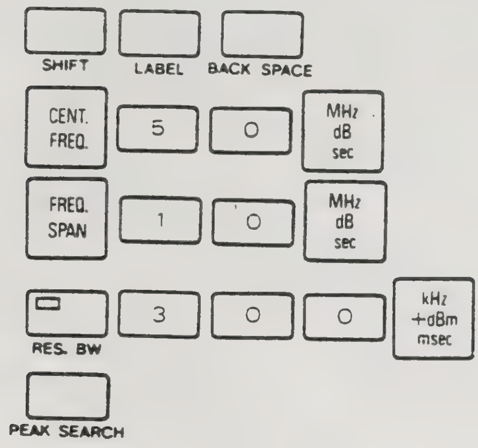
(a) Connect the CAL OUT connector on the TR4172 to its INPUT-1 connector, then set up the instrument as follows:



(b) Through the above setup, the signal response at a 300 kHz resolution bandwidth is viewed on TRACE A, while that at a 1 MHz resolution bandwidth is viewed on TRACE B. Adjust R221 until the signal level at 1 MHz resolution bandwidth is identical to that at 300 kHz resolution bandwidth.

(7) Total gain adjustment

(a) Connect the CAL OUT. to INPUT-1, then set up the TR4172 as follows:



(b) Adjust R151 until the marker level readout is -20.0 dBm ±0.1 dB.

11-6-8. Tracking Generator Block Adjustment (MEP-346 circuit diagram No. 54)

(Board and circuit Nos.
Tracking Generator-1 BLJ-010128 No. 55
Tracking Generator-2 BLJ-010129 No. 56
Tracking Generator-3 BLJ-010130 No. 57)

Instruments required: * Spectrum analyzer
* Signal generator
* High impedance probe

(1) 3.33 MHz local OSC adjustment

(a) Set the POWER switch to STANDBY, and remove the TG block (MEP-346) from the chassis. For quick removal, temporarily remove the standard block (MEP-342) and counter switch (MEP-349) before removing the TG block. Use extension cables to establish the original electrical connections between the TG block and the analyzer mainframe. (See Figure 11-57.)

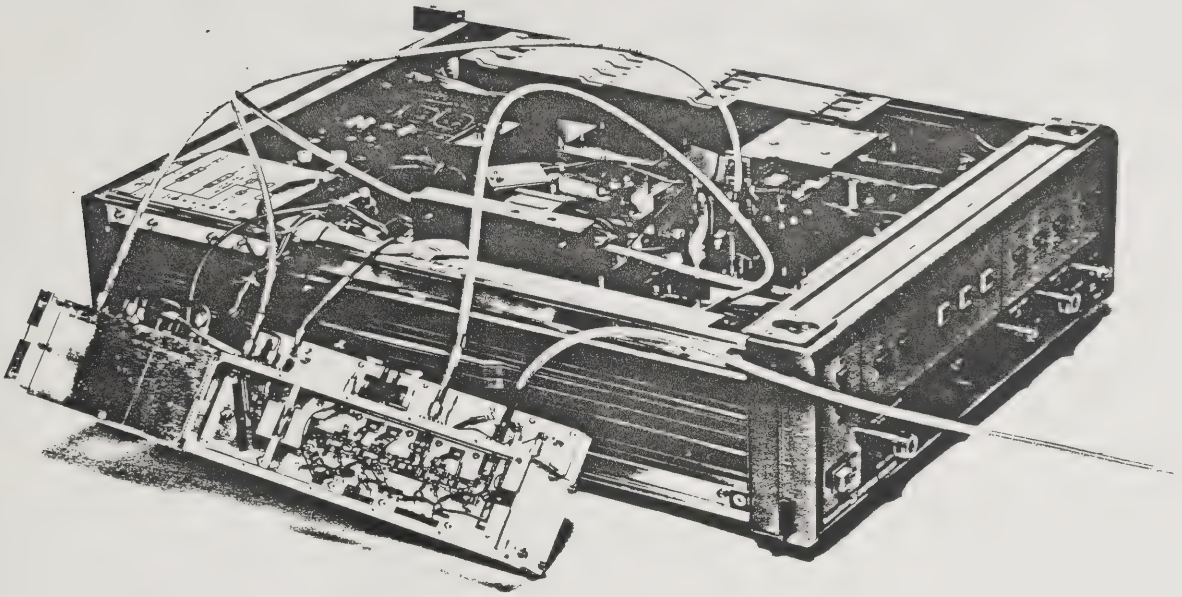


Fig. 11-57 MEP-346 removal

(b) Set the POWER switch to ON. Set the T.G. FREQ. ADJ control on the front panel to the center position. Then press PHASE to select the phase measurement mode.

(c) Connect J40 (3.33 MHz local output for phase) on the Tracking Generator block to the counter to count its output frequency. Adjust C122 on Tracking Generator-2 (BLJ-010129) until the counter readout is 3.333333 MHz ±5 Hz.

(2) 30 MHz B.P.F. adjustment

(a) Press MASTER RESET to initialize the TR4172, then press T.G. to activate the TRACKING GENERATOR OUTPUT.

(b) Connect the external spectrum analyzer to J35 (206 MHz IF output) on the Tracking Generator block (MEP-346) to observe its signal response. At this time, set up the external analyzer for a 206.33 MHz center frequency.

(c) Connect the output of a signal generator to J38 (33.3 MHz local input) on the Tracking Generator block (MEP-346). Set the signal generator output at 33.33 MHz ±5 MHz, approximately -5 dBm.

(d) The 30 MHz B.P.F. response can be observed at the J35 (206.33 MHz) IF output by changing the output frequency of the signal generator. Adjust C156, C159, and C162 until the filter response is symmetrical around 206.33 MHz and its maximum level is attained. A slight ripple within the pass bandwidth may be ignored.

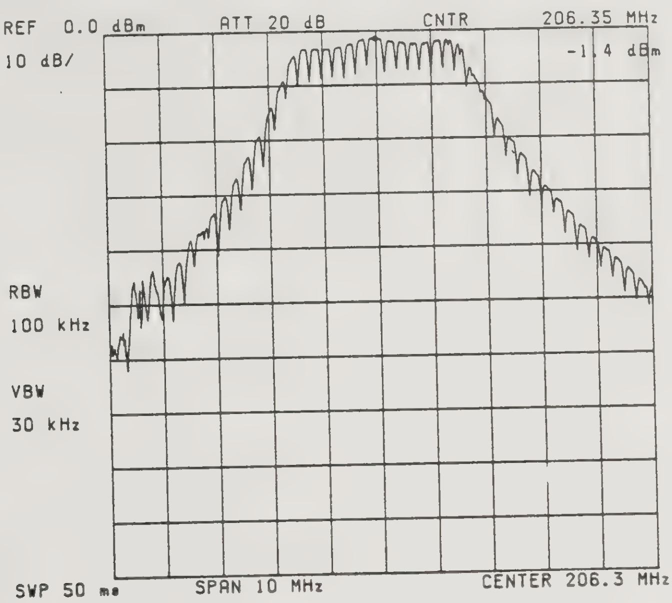


Fig. 11-58 TG 30 MHz B.P.F. adjustment

(e) Disconnect the signal generator from J38 on the Tracking Generator block (MEP346), and restore the original connection.

(3) 206 MHz B.P.F. adjustment

(a) This adjustment should be made directly after the 30 MHz B.P.F. adjustment. Connect the output of the signal generator to J36 (176 MHz local input) on the Tracking Generator block (MEP-346). Set the signal generator output to about 176.33 MHz ±10 MHz, +5 dBm.

(b) The 206.33 MHz B.P.F. response can be observed at the J35 (206.33 MHz IF output) by changing the output frequency of the signal generator. Adjust C179, C184, and C185 until the filter response is symmetrical around 206.33 MHz and its maximum level is attained. (See Figure 11-59.)

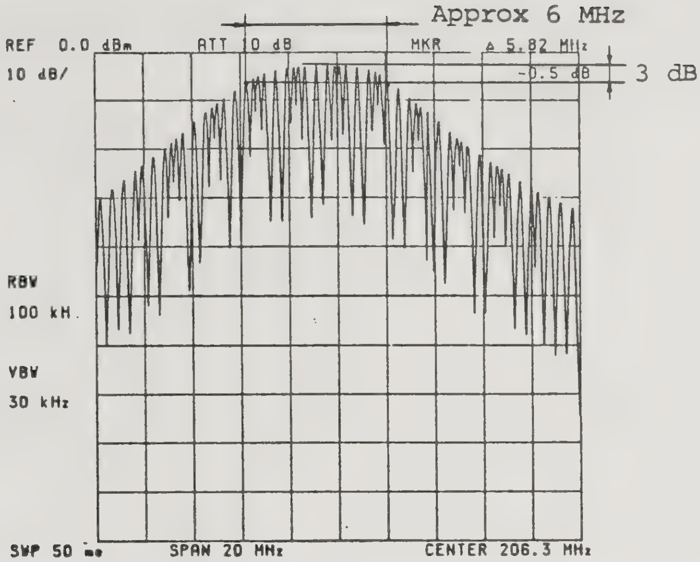


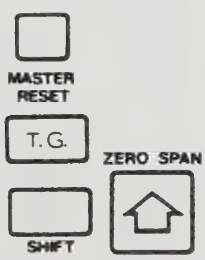
Fig. 11-59 TG 206 MHz B.P.F. adjustment

(c) Disconnect the signal generator from J36 of the Tracking Generator block (MEP346) and restore the original connection. Also disconnect the external spectrum analyzer from J35 and restore the original connection.

(4) TG output 2046 MHz trap adjustment

(a) Remove the shield case cover from the Tracking Generator-1 block (BTF-010128).

(b) Update the TR4172 panel setup as follows:



(c) Connect the external spectrum analyzer to the TRACKING GENERATOR OUTPUT of the TR4172 to observe the T.G. output signal response. Set up the external analyzer for a center frequency of 2046 MHz.

(d) Adjust C120 on the Tracking Generator-1 block until the 2046 MHz signal response level (TG final IF leakage) observed on the external analyzer is minimized.

(e) Remount the shield case cover on the Tracking Generator-1 block.

(5) TG output frequency response compensation

(a) C105 on the Tracking Generator-1 block (BTF-010128) is a TG output frequency response compensating adjustment which is particularly effective for the frequency range above 1000 MHz.

(b) Check the TG output frequency response with a power meter or the external spectrum analyzer, and adjust C104 until the level in the frequency range above 1000 MHz is almost the same as that in the range between 10 and 1000 MHz.

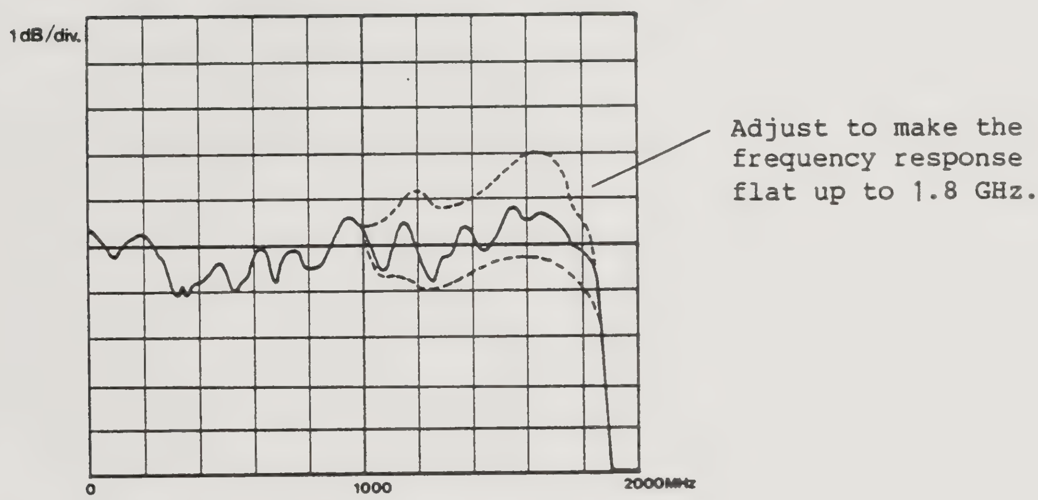


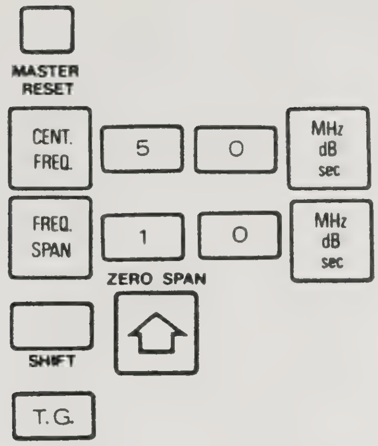
Fig. 11-60 TG output frequency response compensation

(6) TG output level accuracy adjustment

(a) Set the POWER switch to STANDBY. Return the Tracking Generator block (MEP-346) to its original position in the chassis.

(b) Set the POWER switch to ON again, and warm up the instrument for at least 30 minutes.

(c) Set up the TR4172 as follows:



(d) Connect a power meter directly to the TRACKING GENERATOR OUTPUT connector on the TR4172 to check the T.G. output level. Adjust R55 in the Tracking Generator-1 block until the T.G. output level is -10 dBm ±0.1 dB.

11-6-9. 3rd Local Block Adjustment (MEP-347 circuit diagram No. 58)

Board and circuit diagram Nos.	2 MHz VCO BLC-010102 No. 62
	39 MHz Mixer BLC-010100 No. 60
	3rd local PLL BLC-010103 No. 63
	23 MHz VCO BLC-010101 No. 61
	176 MHz Mixer BLC-010099 No. 59

Instruments required:
* Signal generator
* Spectrum analyzer
* Standard DC voltage source
* Digital voltmeter
* Frequency counter

(1) 23 MHz VCO voltage-frequency gain adjustment and frequency variation ratio adjustment

This paragraph provides an alignment procedure, when the oscillator FET or varicap for the VCO (230 MHz ±10 MHz) was replaced due to defect.

The voltage-frequency response of the VCO before compensation is shown in the following figure:

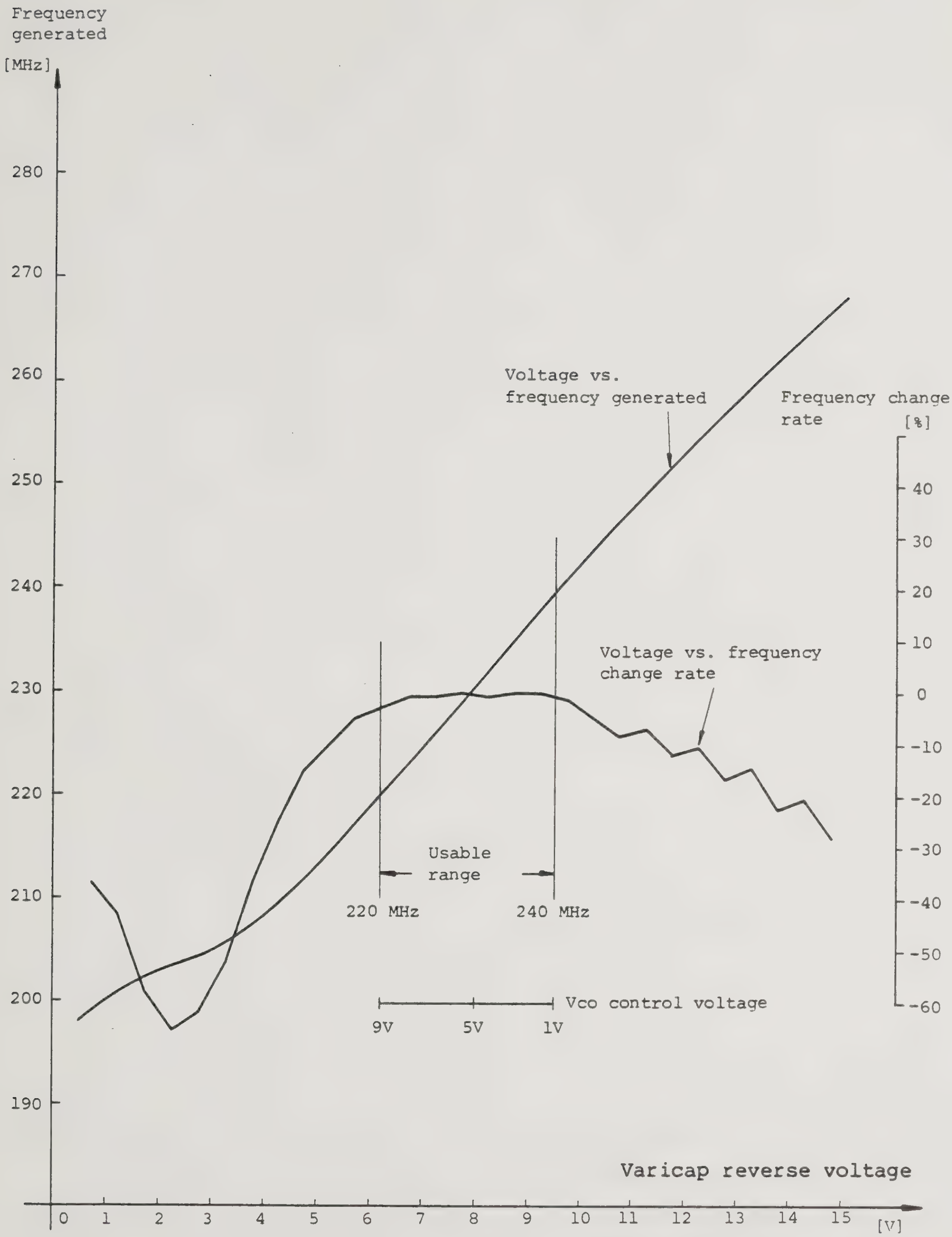


Fig. 11-61 Voltage-frequency response of the VCO

In order to use the constant-variation portion of the response, the reverse voltage applied to the varicap is set at about 8 V. As a result, the frequency variation ratio before compensation is within approximately 5% of the given voltage range.
For adjustment, vary the offset voltage for the varicap to search for the best point of frequency variation ratio before compensation, then fix the offset voltage there. The voltage is normally 8 V ±0.5 V. Adjust the oscillation frequency at that voltage (the center of the variable frequency range). Then adjust the VCO voltage-frequency gain response in the range which will not be subject to compensation. In the range where compensation is required, adjust the voltage at which copensation becomes effective. Some varicap may not require any compensation. Whenever unsoldering is required for a circuit component, be sure to switch off the instrument.

(a) Remove the shield case cover from the 23 MHz VCO. Disconnect the input connection from the 3RDA S. IN, and connect a standard DC output to it. Set the DC output to 5.000 V. Remove the two jumper wires (at D26 and D30) from the board.

(b) Adjust R80 until the voltage at TP-1 is 0.00 V.

(c) Check the voltage across C105 and ground, and adjust R48 until the voltage is -8.0 V.

(d) Set C105 to its center position. Connect the frequency counter to J182 on the board.

(e) Adjust the length of L175 until the counter readout is around 23.00 MHz. Make fine adjustment with C101 until the frequency reading is exactly 23.0000 MHz.

(f) While increasing the output DC from 3 to 7 V in 1 V steps, adjust R88 so the frequency increases at 250 kHz steps.

(g) Increase the DC output from 1 to 9 V in 0.5 V steps (125 kHz steps) to observe the overall frequency veriation ratio. Adjust the varicap offset voltage (-8 ±0.5 V) with R48 so the overall frequency variation ratio is small and the portion requiring no compensation exists in a range from 1 to 5 V or 5 to 9 V. The desirable overall frequency variation ratio is less than 2%.

(h) When compensation is required for the voltage range between 5 and 9 V, install the jumper wire for D30; when that for the voltage range between 1 and 5 V is required, install the jumper wire for D26. It is preferred that compensation be made to only one of the two voltage ranges.

(i) Set the DC output to 5.000 V, and adjust C101 again until the frequency is 23.0000 MHz. When compensation is made to the voltage range between 1 and 5 V, set the DC output to 9.000 V, and adjust the voltage-frequency gain response in the range which has not been subject to compensation (when compensation was made to the voltage range between 5 and 9 V, set the DC output to 1.000 V). Adjust R88 until the frequency is 22.000 MHz (when the standard DC source is set at 1.000 V, set the frequency to 24.0000 MHz).

(j) Adjust the voltage-frequency gain response in the range subject to compensation. Set the output of the standard DC source to 1.000 V, and adjust R92 until the frequency is 24.0000 MHz (or set the voltage source to 9.000 V, and adjust R99 until the frequency is 23.0000 MHz).

(k) While increasing the DC output from 1 to 9 V at 0.5 V steps (125 kHz steps), verify that the overall frequency variation ratio is less than 2%.

(l) If the error without compensation is less than 2%, leave the two jumper wires detached.

(m) Disconnect the DC source from the 3RDA S. IN and restore the original connection. Remount the shield case cover on the VCO block.

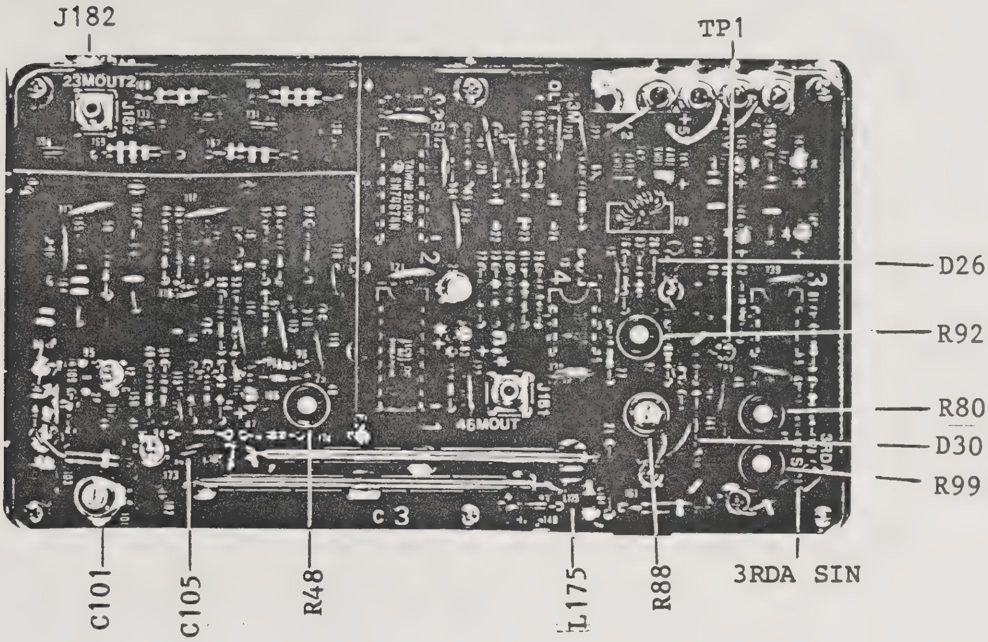


Fig. 11-62 Location of adjustments on the 23 MHz VCO (BLC-010101)

(2) 2 MHz VCO voltage-frequency gain adjustment and frequency variation adjustment

Adjustment of the 2 MHz VCO is similar to that for the 23 MHz VCO described above.

(a) Remove the shield case cover from the 2 MHz VCO block. Disconnect the input connection to the 3RD B S IN, and connect the DC output. Set the output to 5.000 V. Remove the two jumper wires (at D36 and D40) from the board.

(b) Check the voltage at TP-1, and adjust R91 until the voltage is 0.00 V.

(c) Check the voltage across C115 and GND, and adjust R58 until the voltage is -8.0 V.

(d) Set C111 to the center position. Connect the frequency counter to J191 on the board.

(e) Adjust the length of L185 until the counter readout is about 2.00 MHz. Make finer adjustment with C111 until the frequency reads exactly 2.0000 MHz.

(f) While increasing the DC output from 3 to 7 V at 1 V intervals, adjust R99 so the frequency increases at 25 kHz intervals.

(g) Search for the varicap offset voltage (normally 8 V $\pm$0.5 V) which gives the optimum frequency variation ratio, by adjusting R58. The desirable frequency variation error is less than 2%.

(h) When compensation is desired between 5 and 9 V, install the jumper wire on D40; when compensation is desired between 1 and 5 V, install the jumper wire for D36. It is preferred that compensation be made to only one of the voltage ranges.

(i) Set the output of the DC source to 5.000 V, and adjust C111 again until the frequency is 2.0000 MHz.

(j) Adjust the voltage-frequency gain response for the uncompensated portion with R99. When compensation is made between 5 and 9 V, adjust R212; when compensation is made between 1 and 5 V, adjust R108. Verify that a voltage variation from 1 to 9 V causes a frequency variation from 2.1000 to 1.9000 MHz, and the overall frequency variation error is less than 2%.

(k) If the error is less than 2% without compensation, the two jumper wires should be removed from the board.

(l) Disconnect the voltage source from the 3RD B S IN, and restore the original connection. Remount the shield case cover on the VCO block.

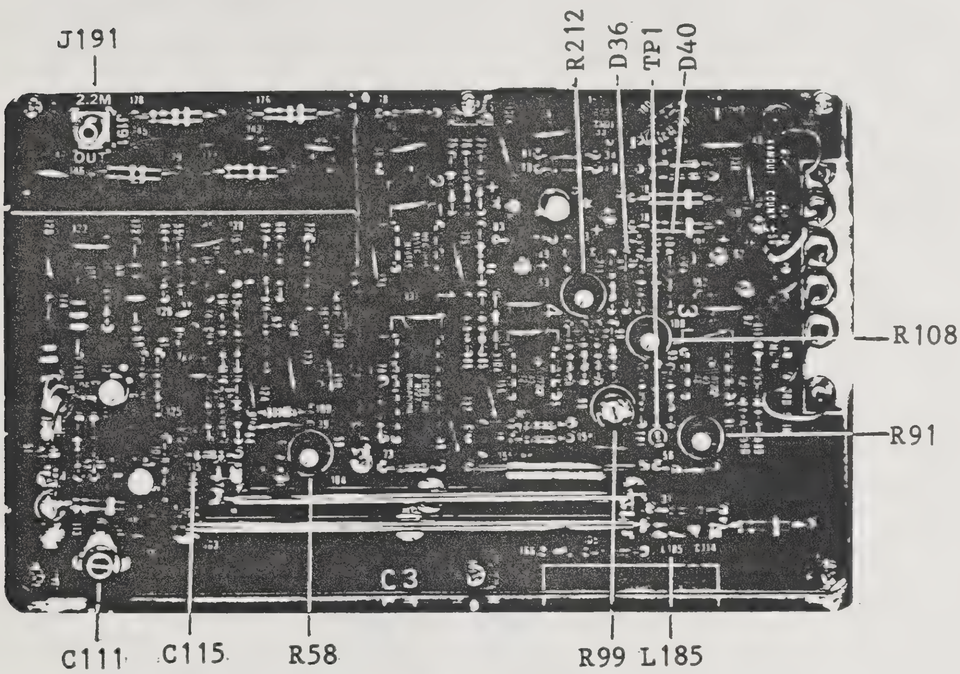


Fig. 11-63 Location of adjustments on the 2 MHz VCO (BLC-010102)

(3) 39 MHz mixer oscillator and B.P.F. adjustment

(a) Remove the shield case cover from the 39 MHz mixer block. Connect the external spectrum analyzer to J91 to observe the 39 MHz quartz oscillator output leaking from the mixer. The leakage level should be approximately -40 dBm.

(b) While monitoring the level of the 39 MHz signal, gradually turn the L71 slug until the signal level is 0.5 dB below the original level.

(c) Connect the signal generator output to J91. Set up the generator for a frequency of about 2 MHz ±500 kHz, and a 0 dBm level. Connect the external spectrum analyzer to J92, and observe the 41 MHz output signal. The output level should be approximately -10 dBm.

(d) While varying the output frequency of the signal generator, observe the response of the 41 MHz B.P.F. with the external spectrum analyzer. Adjust C48, C51, C55, and C58 until the output level variation is less than 0.2 dB in the frequency range of 41 MHz ±100 kHz, and the response is centered on that frequency. (See Figure 11-64.)

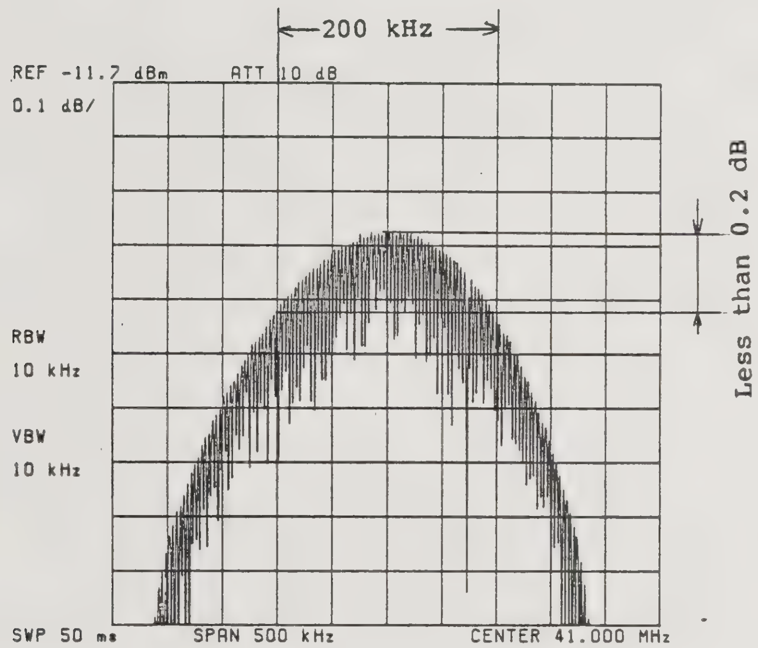


Fig. 11-64 41 MHz B.P.F. adjustment

(e) The output level at J92 should be less than -10 dBm ±0.5 dB at 41 MHz. The output level and B.P.F. bandwidth are affected by the distances between L72 and L73, and L74 and L75. Adjust these distances.

(f) Restore the original connections for J91 and J92, and remount the shield case cover on the mixer block.

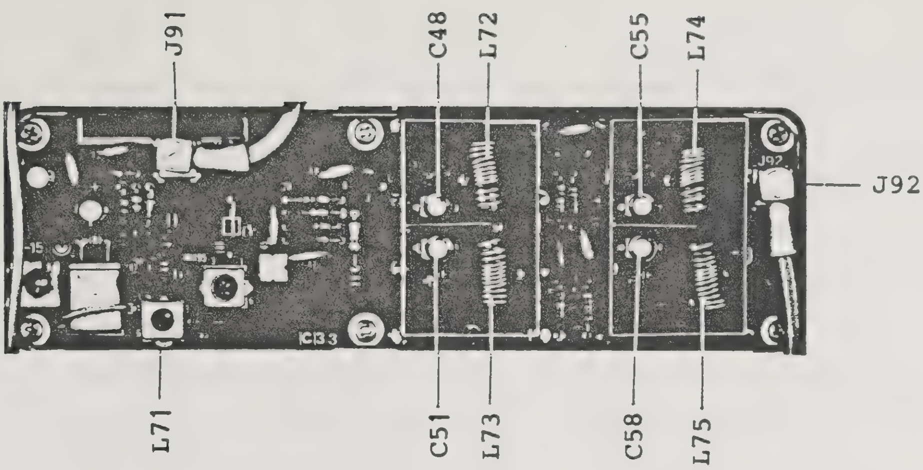


Fig. 11-65 Locations of adjustments on the 39 MHz mixer (BLC-010100)

(4) 176 MHz mixer oscillator and B.P.F. adjustment

Whenever resoldering is required for circuit components, be sure to set the POWER switch to STANDBY.

(a) Remove the shield case cover from the 176 MHz mixer. Disconnect the wiring to the COUN OUT and ON/OFF. Connect the standard DC output (+15 V) to ON/OFF, and connect the external spectrum analyzer to the COUN OUT. Set up the external analyzer for a center frequency of 153.3 MHz.

(b) While monitoring the level of the 153.3 MHz quartz oscillator output with the external spectrum analyzer, adjust C84 to position the level at 0.2 dB below the oscillation starting point as shown in the following figure.

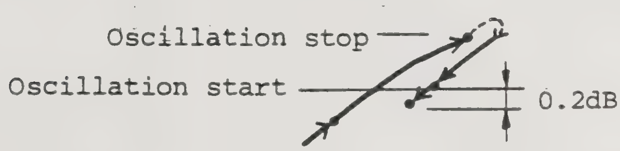


Fig. 11-66 153.3 MHz quartz oscillator adjustment

(c) Adjust L134 coil pitch so the maximum 153.3 MHz signal level is attained.

(d) Adjust the distance between L132 and L133 so the 153.3 MHz signal level is +2 dBm. Adjust only, L133 leaving L132 as it is.

(e) Connect the output of the signal generator to J161. Set up the signal generator output for a frequency of about 23 ±1 MHz and level of around -10 dBm. Disconnect the wiring from the RF OUT on the board, and connect the external spectrum analyzer. Since the output level at RF OUT is approximately +9 dBm, use the input attenuator in the external analyzer to prevent input overload. Set up the external analyzer for a center frequency of 176.3 MHz.

(f) While varyfing the output frequency of the signal generator, observe the response of the 176 MHz B.P.F. Adjust F166 and F167 so the output level variation is less than 0.5 dB in the frequency range of 176.33 ±1 MHz, with the filter response symmetrical around the center frequency and the output level maximized. Adjust the peak level with C112.

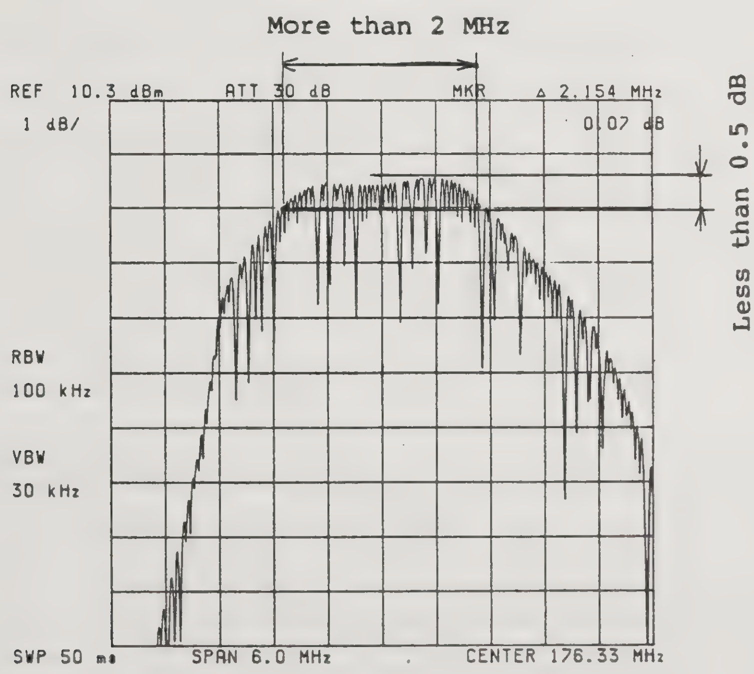


Fig. 11-67 176 MHz B.P.F. adjustment

(g) Verify that the output level is approximately +9 dBm ±1 dB at 176.33 MHz.

(h) Restore the original wiring and connections to the COUN OUT, ON/STANDBY, RF OUT, and J161, then remount the shield case cover on the 176 MHz mixer.

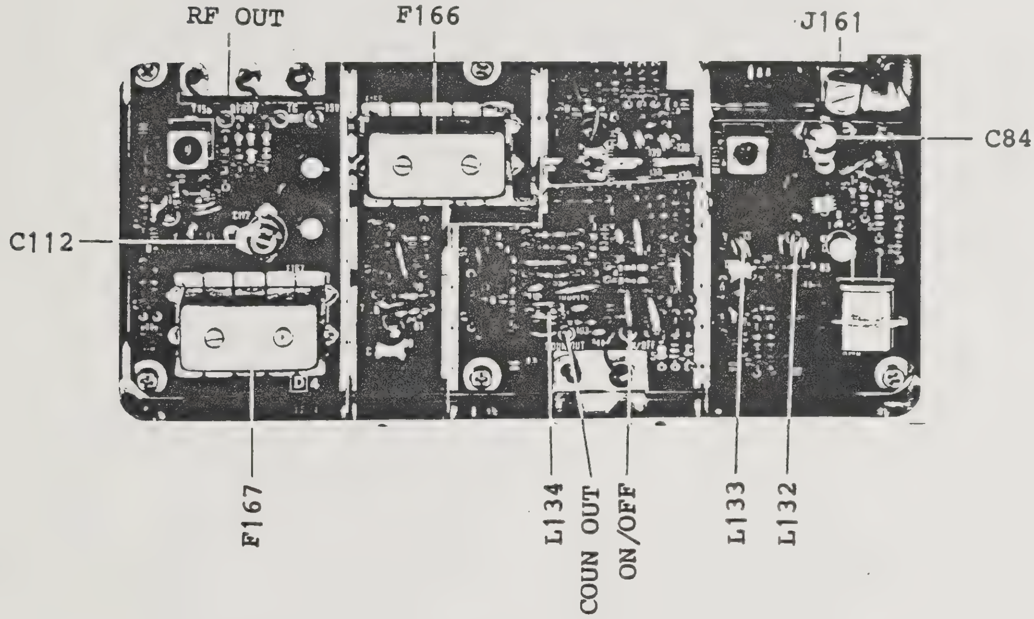


Fig. 11-68 Location of adjustments on the 176 MHz mixer (BLC-010099)

11-6-10. 1st Local PLL Block Adjustment (MEP-348 circuit diagram No. 64)

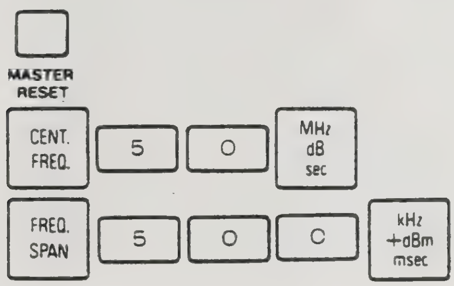
Block and circuit diagram Nos.
100/101 MHz oscillator (BLC-010115) No. 67
100/101 MHz OSC PLL (BLB-010120) No. 72
ANALOG PHASE DETECTOR (BLB-010117) No. 69
DIGITAL PHASE DETECTOR (BLC-010118) No. 70
PLL filter (BLB-010119) No. 71
1st local PLL mixer (BLB-010116) No. 68
2-4 GHz local PULSE GENERATOR (BTB-010114) No. 66
Isolation amplifier (BTB-010113) No. 65

Instruments required:
* Spectrum analyzer with tracking generater
* Standard DC voltage source
* High impedance probe
* Oscilloscope

(1) 100/101 MHz OSC PLL adjustment

(a) Remove the shield case cover from the 100/101 MHz OSC PLL block. Using the external spectrum analyzer with a high impedance probe attached, observe the signal response at the Q12 collector on the board. Set up the external analyzer for center frequency of 35 MHz.

(b) Set up the TR4172 as follows:



(c) Check the 35 MHz signal level with the external analyzer, and adjust L131, L132, and L133 until the maximum signal level is attained.

(d) Observe the signal response at the Q14 collector with the external analyzer. At this time, set up the external analyzer for a center frequency of 105 MHz. Adjust L134, C96, and C98 until the maximum 105 MHz signal level is attained.

(e) Remount the shield case over on the 100/101 MHz OSC PLL block.

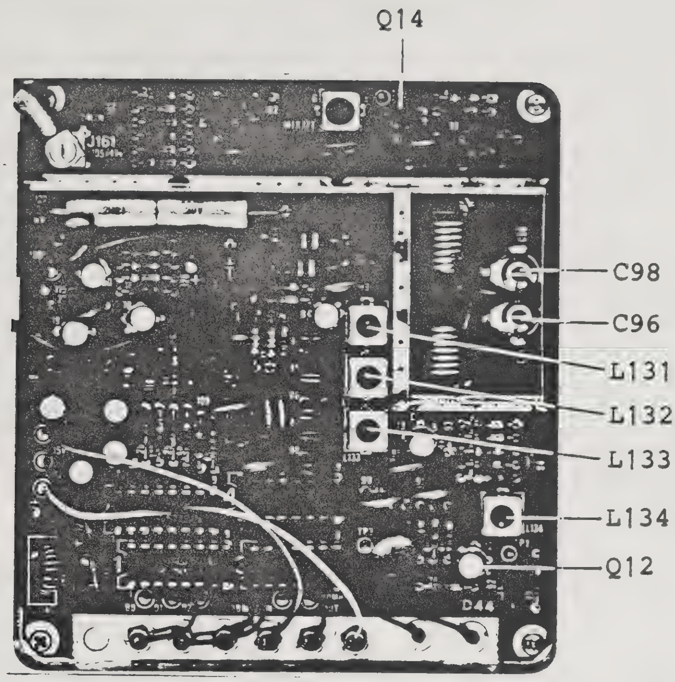


Fig. 11-69 Locations of adjustments on the 100/101 MHz OSC. PLL (BLB-010120)

(2) 100/101 MHz OSC adjustment

(a) Remove the shield case cover from the 100/101 MHz OSC block. Set the POWER switch to STANDBY, disconnect the wiring from the 100/101 MHz PLL IN terminal, and connect the standard DC output to the terminal. Set the output to approx 9.7V

(b) Set the POWER switch to ON, and set up the TR4172 as follows:

[CENT. FREQ.] [5] [0] [MHz dB sec]

[FREQ. SPAN] [5] [0] [0] [kHz +dBm msec]

(101 MHz Oscillator oscillates)

(c) Connect the external spectrum analyzer to J116 and observe the output signal response. Since the output at J116 is 101 MHz in frequency and +23 dBm in level, use the input attenuator of the external attenuator to prevent input overload.

(d) Adjust C82, C87, and C88 until the 101 MHz signal level is maximized. Repeat this adjustment several times as C87 and C88 affect each other.

(e) Press [CENT. FREQ.] [7] [9] [MHz dB sec] to activate the 100 MHz oscilator. Verify that the difference in the output signal levels (at J116) at 100 and 101 MHz is no more than 1 dB. If the difference is more than 1 dB, adjust C82, C87, and C88 again.

(f) Set the POWER switch to STANDBY. Restore the original wiring to the 100/101 MHz PLL IN terminal and J116.

(g) Set the POWER switch to ON, and warm up the instrument for at least 10 minutes. Set up the TR4172 as in step (b) to activate the 101 MHz oscillator and phase lock.

(h) Check the voltage across TP-1 and GND, and adjust X112 until the the voltage is +3.5 V.

(i) Press [CENT. FREQ.] [7] [9] [MHz dB sec] to activate the 100 MHz oscillator and phase lock.

(j) Check the voltage across TP-1 and GND, and adjust X111 to obtain +3.5 V

(k) Remount the shield case cover on the 100/101 MHz OSC block.

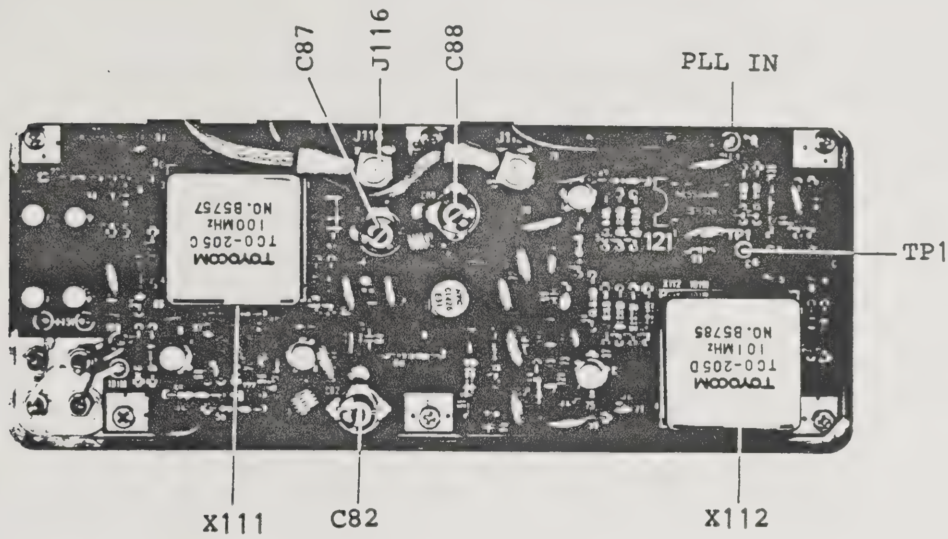
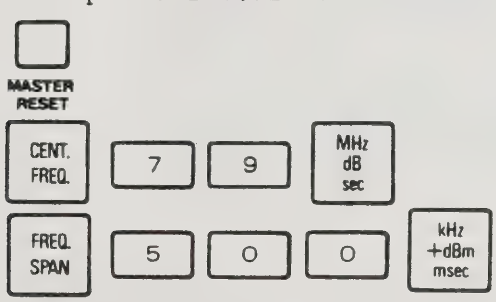


Fig. 11-70 Locations of adjustments on the 100/101 MHz OSC (BLL-010115)
(Circuit diagram No. 67)

(3) 2-4 GHz Pulse Generator (BTB-010114) adjustment

(b) Disconnect the wiring from J69 (first local PLL P.G. output) on MEP-348, and instead, connect the external spectrum analyzer to this terminal. Set up the external analyzer for direct observation of the frequency range between 2 GHz and 4 GHz. Since the signal level at J69 is considerably high, use the input attenuator in the external analyzer to prevent input overload.

(b) Set up the TR4172 as follows:



(c) The above setup activates the 100 MHz comb signal. Adjust R13, C24, and C25 so the comb signal level is more than -25 dBm in the 2-4 GHz frequency range. The comb signal spectrum within this frequency range should have minimum dip.

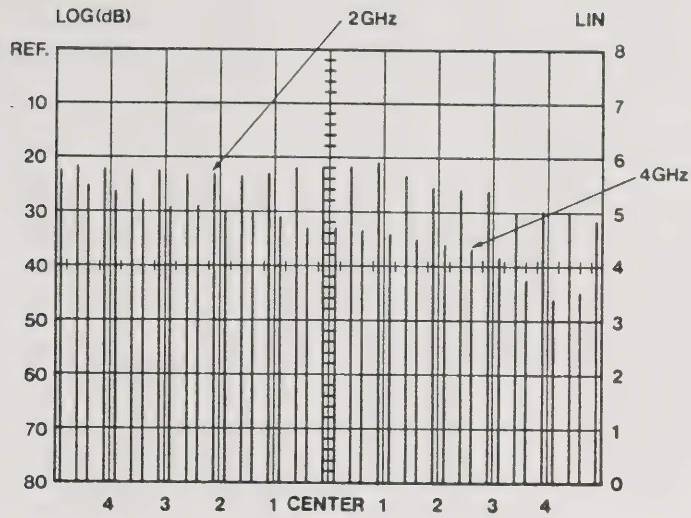


Fig. 11-71 Comb signal adjustment

(d) Press [CENT. FREQ] [5] [0] [MHz dB sec] to activate the 101 MHz comb signal. Verify that the comb signal level is more than -25 dBm in the 2.02-4.04 GHz frequency range.

(e) Restore the original wiring to J69 on MEP-348.

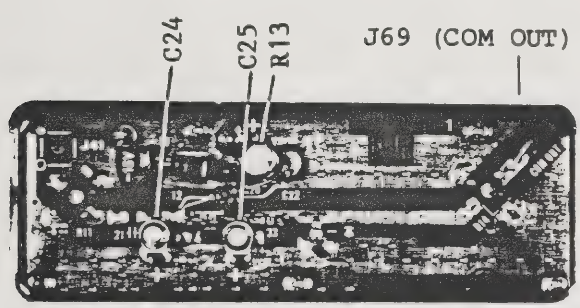


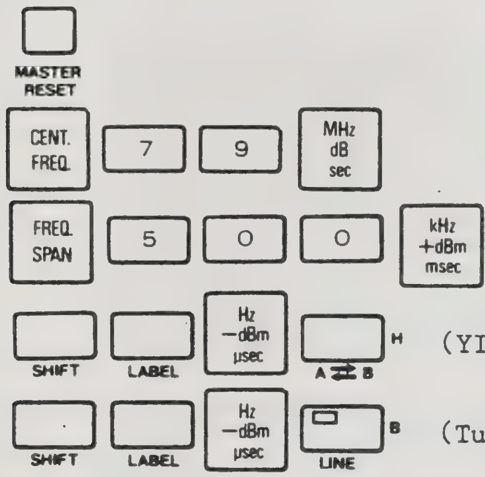
Fig. 11-72 Locations of adjustments on the 2-4 GHz Pulse Generator (BTB-010114)

(4) Analog phase detector and PLL filter adjustment (BLB-010117 / BLB-010119

Whenever resoldering is required for a circuit component, be sure to switch off the instrument.

(a) Remove the shield case cover from the Analog phase detector and PLL filter block. Disconnect the wiring from the PLL OUT terminal on the PLL Filter board.

(b) Using the external spectrum analyzer with a high impedance probe attached, observe the signal response at the Q16 source on the Analog phase detector board. Update the panel setup for the TR4172:



(YIG LOCK 2 OFF)

(Tune FM Data (YIG I/O))

(c) Adjust the DATA knob to change Step FM setting, and observe the beat signal response with an oscilloscope.

(d) Confirm that the YTO beat signal is ±0.6 V with the center voltage of 0 V.

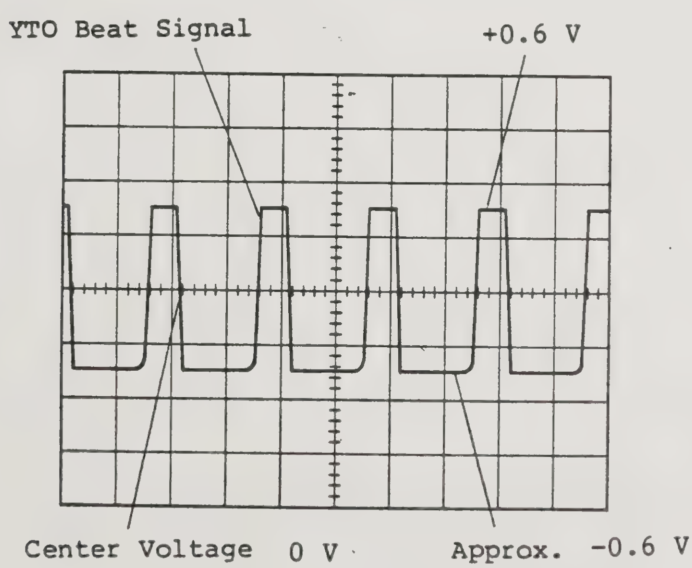


Fig. 11-73 Beat signal offset adjustment

(e) Press MASTER RESET switch. Disconnect the wiring from the D. IN and A. IN terminals on the PLL filter board. Connect the output of the tracking generator contained in the external spectrum analyzer to the D. IN terminal, and observe the signal response at D. OUT with the external analyzer. Set the tracking generator output level to about -10 dBm.

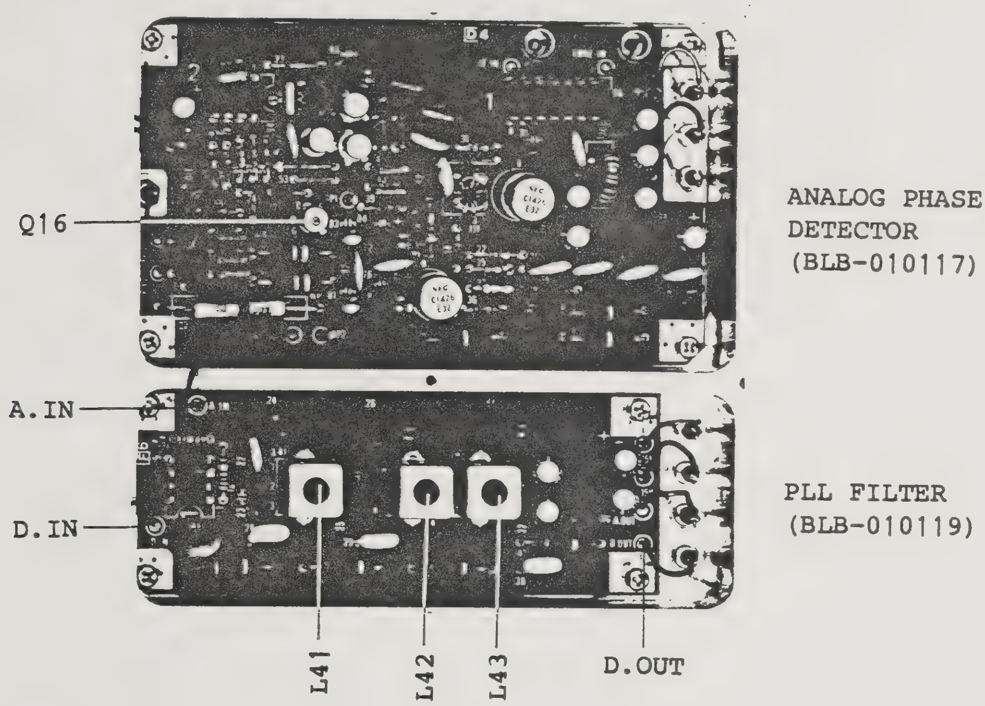


Fig. 11-74 Location of adjustments on the Analog phase detecter board (BLB-010117) and the PLL filter board (BLB-010119)

(f) Observe the PLL filter response of 0-5 MHz. Confirm that the cutoff frequency is 200 kHz.

(g) Connect the tracking generator output (of the external analyzer) to the A. IN terminal to observe the frequency band between 0 and 5 MHz. Adjust L42 until the trap frequency is 1 MHz. Adjust L41 until the trap frequency is 2 MHz.

Adjust L43 until the trap frequency is 500kHz

(b) Restore the original wiring to terminals D. IN and A. IN. Remount the shield case cover on the A phase detector and PLL filter block.

	Block	Test point and adjustment	Adjustment item and specifications
1	Display section power supply (BGP-010198)	TP-1 R33 TP-2 R63 TP-3 R50 TP-4 R58 TP-5 R44	+5 V ±0.05 V +135 V ±0.2 V -15 V ±0.01 V +25 V ±0.01 V +15 V ±0.01 V
2	High voltage power supply (BLC-010-204)	TP-K R62 Anode R64 R63	-3.000 kV +12 kV to +13 kV Intensity adjustment Focus adjustment
3	CRT Driver (BGK-010184)	J182 pin 1 R203 J182 pin 5 R199 R202 R200 GAIN R193 POSI. R192 GAIN R195 POSI. R194 R196 R201 C261 R197 R198 C248	+75 V +75 V Halation adjustment Pattern distortion adjustment Y-axis adjustment X-axis adjustment Intensity adjustment Asting adjustment Focus adjustment (center) Focus adjustment (both sides) Z-axis response adjustment
4	Memory (BGP-010192)	TP-2 R125 TP-4 R126	DATA knob adjustment
5	D/A Converter (BGP-010188)	Q61 emitter R91	+10 V ±10 mV
6	RAMP. GENERATOR (BGP-010185)	P1-9AB R95 R64, R65, R83 R124 R130	0 V ±5 V (Ramp output voltage adjustment) Scan time accuracy adjustment Analog sweep adjustment Rewriting position adjustment
7	ANALOG I/O (BPG-010186)	R315, R311 R130, R134 R164, R158, R156 R147, R150, R153 R190, R188 R183, R180 Y-axis gain R240 Y-axis position R236 X-axis gain R254 X-aixs position R256 C354, C375, C363 R293, R306 R174	Offset null adjustment Log. Mag. Amp. adjustment Phase Mag. Amp. adjustment Horizontal scale adjustment Vertical scale adjustment Character adjustment Line generator adjustment Marker adjustment Analog sweep positional adjustment

	Block	Test point and adjustment	Adjustment item and specifications
8	A/D Converter (BGP-010187)	TP-4 R177	Sample detector adjustment
		TP-4 R178	Positive detector adjustment
		TP-4 R176	Negative detector adjustment
		R179, R180	Y-axis A/D converter adjustment
		R175	Slope detector adjustment
		R181	X-axis A/D converter adjustment
9	LOG AMP (BLP-010231)	L679, L672	3.3 MHz filter adjustment
		R212, R145	BW switching level adjustment
		R238, R301, R355 R157	Log linearity and gain adjustment
		R335	DC offset adjustment
		R352, R294	Linear adjustment
		R254, R263, R272	Linear step amp. adjustment
10	IF -1 (BLP-010229)	C372, C376, C380 L592, L594	1 MHz B.P.F. adjustment
		First stage L601, C422 Second stage L604, C438 Third stage L607, C454	LC filter adjustment
		C484, C506, C529 C552	Crystal filter frequency adjustment
		C482, C505, C528 C551	Crystal filter balance adjustment
		C486, C509, C532 C555	Crystal filter frequency adjustment
		10 dB R136 20 dB R137	Step amp. adjustment
		R127	Total gain adjustment
		B.W. 10 kHz R205 B.W. 3 kHz R235 B.W. 10 Hz R319	Inter-bandwidth level difference adjustment
11	IF -2 (BLP-010230)	First stage L514, C394 Second stage L522, C457	LC filter adjustment
		C421, C424	Crystal filter frequency adjustment
		C420	Crystal filter balance frequency
		C702, C696, C681	Crystal filter 7 Hz adjustment
		30 dB R139 40 dB R140 50 dB R220	Step amp. adjustment
		1 dB R172 2 dB R164 4 dB R156 8 dB R148	1 dB step attenuator adjustment

	Block	Test point and adjustment	Adjustment item and specifications
11	IF-2 (BLP-010230)	B.W. 10 kHz R317 B.W. 3 kHz R261 B.W. 10 Hz R263 B.W. 7 Hz R669	Inter-bandwidth level difference adjustment
12	PHASE and GROUP DELAY (BLP-010205)	TP-2 R292 TP-2 R295 TP-4 R301 TP-6 R297 TP-5 R307 C422, C425 C386, C391 C351, C505 C371, C506 R273, R265 R281 R285 R283	Offset null adjustment +10 V adjustment Ref. adjustment Control voltage adjustment Offset null adjustment 3.3 MHz filter adjustment 33.3 MHz filter adjustment 30 MHz filter adjustment Output level adjustment Group delay offset adjustment Group delay offset fine adjustment Phase offset adjustment
13	RF power supply (BLF-010370)	TP-1 R33 TP-2 TP-3 R39 TP-4 R47 TP-5	-15 V ±0.01 V +12 V +15 V ±0.01 V +5 V ±0.01 V GND
14	50 MHz STD (BLB-010135)	L121, L122, L123, L124, L125, L126 R61	50 MHz tuning adjustment Output level adjustment
15	ATT I/O (BGN-010220)	R165 R96	Offset adjustment Frequency response compensation gain adjustment
16	YIG I/O (BGN-010219)	TP-4 R99 TP-4 R100 TP-1 R95 TP-2 R94 R93 R98 R101	Offset null adjustment +10 V adjustment YIG main D/A adjustment YIG FM D/A adjustment YIG main gain adjustment YIG main span accuracy adjustment Overall span accuracy adjustment
17	YIG Driver (BLC-010224)	R53, R46 R42 R64 R59	Offset null adjustment YIG main offset adjustment YIG FM gain adjustment YIG FM span accuracy adjustment
18	3rd LO I/O (BGN-010221)	TP-4 R97 TP-1 R90 TP-2 R96 TP-3 R98 R87, R88, R89 R85	+10 V adjustment Tune D/A A adjustment Tune D/A B adjustment Tune D/A C adjustment Sweep gain A adjustment Sweep offset A adjustment

	Block	Test point and adjustment	Adjustment item and specifications
18	3rd LO I/O (BGN-010221)	R94, R93, R95 R91 R86 R92	Sweep gain B adjustment Sweep offset B adjustment 20 MHz VCO span accuracy adjustment 2 MHz VCO span accuracy adjustment
19	Counter (BLJ-010131)	TP-1 R80 R75	-1.8 V adjustment Schmitt trigger sensitivity adjustment
20	RF (BLP-010133)	C237 C239, C240, C253 C254, C255, C264 L430, L432, C433 C375 C304 C292, C293, C294 C295, C296, C297 C310, C312 C342, C343, C344 C338, C339, C340 C341 R221 R151	204 MHz OSC adjustment Second local adjustment Fourth local adjustment Third local amp. adjustment 206 MHz B.P.F. adjustment 30 MHz B.P.F. (1) adjustment 30 MHz B.P.F. (2) adjustment 30 MHz B.P.F. (3) adjustment Inter-bandwidth level difference adjustment Total gain adjustment
21	TG-2 (BLJ-010129)	C156, C159 C162 C179, C183, C184 C185	30 MHz B.P.F. adjustment 206 MHz B.P.F. adjustment
22	TG-1 (BTF-010128)	C120 C104 R55	2046 MHz trap adjustment Frequency response compensation adjustment Output level adjustment
23	23 MHz VCO (BLC-010101)	R48 R99, R92 R88 R80 C101	Varicap offset voltage adjustment Linearity adjustment Voltage-frequency gain adjustment Offset voltage adjustment Oscillation frequency adjustment
24	2 MHz VCO (BLC-010102)	R58 R108, R212 R99 R91 C111	Varicap offset voltage adjustment Linearity adjustment V-f gain adjustment Offset voltage adjustment Oscillation frequency adjustment

	Block	Test point and adjustment	Adjustment item and specifications
25	39 MHz MIXER (BLC-010100)	L71 C48, C51, C55, C58	39 MHz OSC adjustment 41 MHz B.P.F. adjustment
26	176 MHz MIXER (BLC-010099)	C48 L134, L133 C112, F166, F167	153 MHz OSC adjustment 153 MHz level adjustment 176 MHz B.P.F. adjustment
27	100/101 MHz PLL (BLC-010120)	L131, L132, L133, L134, C96, C98	35 MHz tuning adjustment 105 MHz B.P.F. adjustment
28	100/101 MHz OSCILLATOR (BLC-010115)	C82, C87, C88 X111 X112	Level adjustment 100 MHz OSC adjustment 101 MHz OSC adjustment
29	2-4 GHz PULSE GENERATOR (BTB-010114)	R13, C24, C25	10 MHz Comb signal adjustment
30	PLL FILTER (BLB-010119)	L43 L42 L41	500 kHz trap adjustment 1 MHz trap adjustment 2 MHz trap adjustment

SECTION 12

PERFORMANCE TEST

12-1. GENERAL

This section describes the procedure for the performance test of TR4172 spectrum analyzer. Major performance can be checked by using the CAL. OUT. (Calibration Output) signal of TR4172.

12-2. PREPARATION AND GENERAL PRECAUTIONS

Instruments and tools required for performance test and calibration are listed in Table 12-1.

12-2-1. Tools and Instruments Required for Performance Test

Table 12-1 Tools and instruments required for performance test

Instrument	Specification	Recommended Model
(1) Synthesized signal generator:	Frequency range: 50 Hz to 1800 MHz Output level: +10 dBm to -30 dBm Output impedance: 50 Ω Output level flatness: ±0.5 dB Frequency modulation: Internal 1 kHz Modulation depth: 10% Must be usable as an external reference.	
(2) Signal generator:	Frequency range: 100 kHz to 1800 MHz Output level: +10 dBm to -30 dBm Output impedance: 50 Ω Output level flatness: ±0.5 dB Frequency accuracy: ±0.01%	

Table 12-1 Tools and instruments required for performance test (Cont'd)

Instrument	Specification	Recommended Model
(3) Low distortion signal generator (or ordinary signal generator plus low-pass filter may be used):	Frequency range: 100 kHz to 900 MHz 2nd harmonic: More than 70 dB of attenuation with respect to an output level of -10 dBm Output level: -10 dBm	
(4) RF power meter :	Frequency range: 100 kHz to 1800 MHz Sensitivity: -30 dBm to +20 dBm Accuracy: ±0.2 dB	
(5) Spectrum analyzer:	Frequency range: 100 kHz to 3.6 GHz	TR4110/4111A (Takeda Riken)
(6) Attenuator:	Frequency range: DC to 500 MHz Attenuation: 0 to 110 dB at 10 dB steps 0 to 11 dB at 1 dB step 0 to 1.1 dB at 0.1 dB step Accuracy: ±0.2 dB for 10 dB ±0.02 dB for 1 dB ±0.002 dB for 0.1 dB	
(7) High isolation power splitter:	Frequency range: 10 kHz to 500 MHz Loss: 6 dB Output isolation: More than 30 dB	
(8) Digital multimeter:	Maximum input voltage: 250 V	TR6841 (Takeda Riken)
(9) Slidac transformer:	Variable voltage range: 80 to 250 V	
(10) Stop watch		
(11) Scale		

Table 12-2 Tools and jigs required for performance test

Item	Stock No.	Remarks
Input cable	MI-02	BNC-BUC (Short)*
Interconnecting cable	MI-61	BNC-BNC (Long)*
Interconnecting cable	MC-37	BNC-SMA
Interconnecting cable	MM-14	SMA-SMA
Interconnecting cable	MC-36	BNC-UM
Interconnecting cable	MM-17	UM-UM
N (P) to BNC (J) conversion adapter	JUG201	JNG-20A/U*
UM to UM linear adapter		UM-QA-JJ
SMA to SMA adapter		HRM-501

Items marked with an asterisk (*) are standard supply accessories.

12-2-2. General Precautions

(1) The instrument should be powered from an electrical outlet supplying the correct local line voltage of 100, 120, or 220 Vac ±10% or 240 Vac $^{+4\%}_{-10\%}$ (50/60 Hz).

(2) Before plugging the instrument into an electrical outlet, be sure to check that the POWER switch is set in the OFF position.

(3) The ambient temperature under which calibration is to be performed should be between +20°C and +30°C, with relative humidity under 80%. The working ambient should be free from excessive dusts, vibration, or noise.

12-3. PERFORMANCE CHECK USING CAL.OUT and T.G. OUTPUT

12-3-1. General

This paragraph describes basic performance check procedures for the TR4172 Spectrum Analyzer using the calibration and tracking-generator outputs of the Analyzer itself.

12-3-2. Initialization

Place the Analyzer in the initial power-on default state. This state may also be entered by pressing MASTER RESET key on the front panel.

12-3-3. Auto Calibration

The instrument can perform an error correction routine for changing resolution bandwidth. Before proceeding with performance check, be sure to execute the error correction routine as described below.

Connect the CAL. OUT. connector to the INPUT-1 connector (both on the RF section). Press [SHIFT] [LABEL] [ ]W to initiate the error correction routine, in which level differences between each resolution bandwidth recorrected.

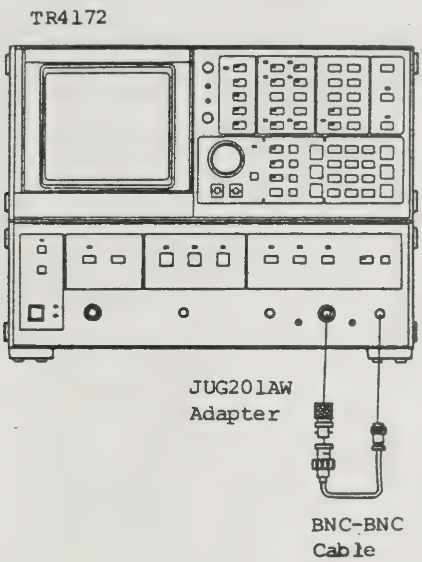
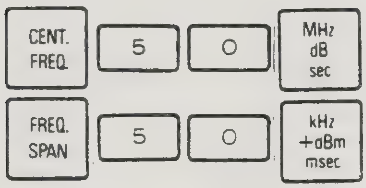


Fig. 12-1 Connecting the CAL.OUT. to INPUT-1

12-3-4. Impact Test

Specification: The instrument must operate normally after its front, rear, left side, and then right side is sequentially lifted to a height of 3 cm (with the opposite sides always resting on the test deck) then is dropped from this height on the deck.

(1) Make the following setup when the instrument is in the initial state.



(2) Lift the front, rear, left side, and then right side of the instrument sequentially to a height of 3 cm (with the opposite sides always resting on the test deck) and drop each side from this heigh on the deck. Verify that no abnormality nor change is observed in its display information, indicator lamps, and so forth after the drop test.

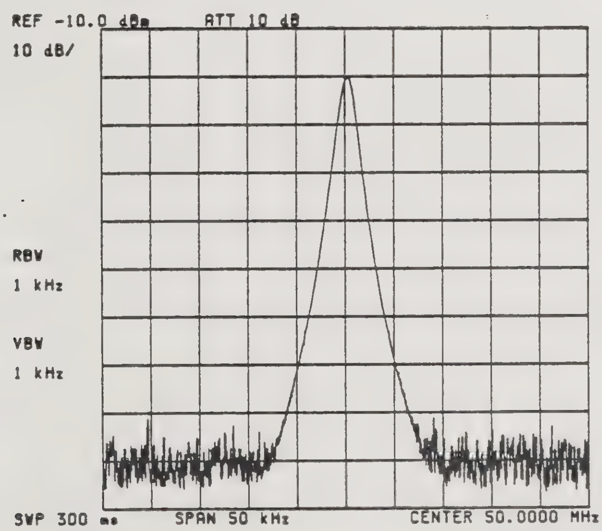
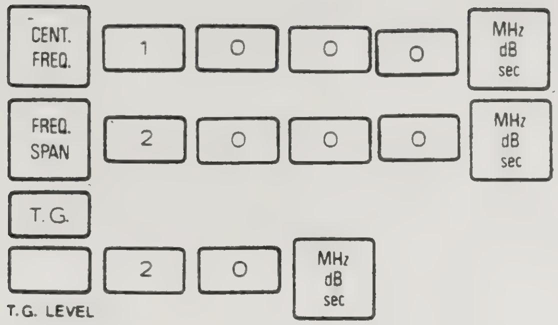


Fig. 12-2 CAL. OUT. signal response

(3) Next, connect the TRACKING GENERATOR OUTPUT connector to the INPUT-1 connector (both on the RF section), and set up the instrument as follows:



(4) Lift the front, rear, left side, and then right side of the instrument to a height of 3 cm (with the opposite sides always resting on the test deck) then drop each side on the deck from this height, and check to make sure that no abnormality or change is observed in the tracking generator output response shown on the display.

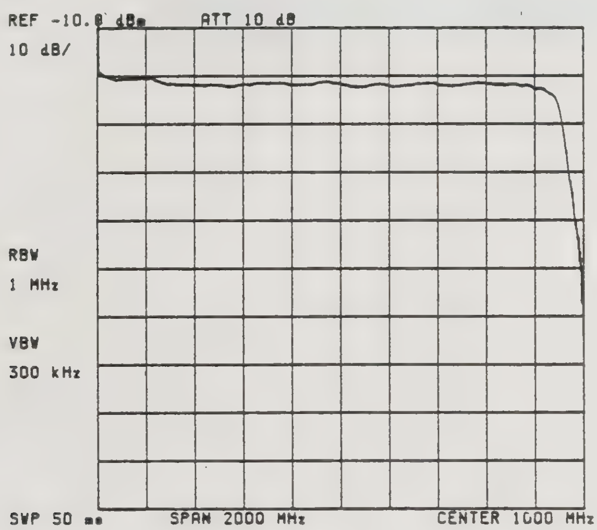


Fig. 12-3 Tracking generator output response

12-3-5. Display Area

Specification: The display area should measure 100 mm by 120 mm or more.

(1) Press the MASTER RESET key to return the instrument in the initial state. Press [LABEL] and arbitrary keys to show label information on the display.

(2) Check to make sure that the display area is more than 100 mm by 120 mm as shown in the following figure:

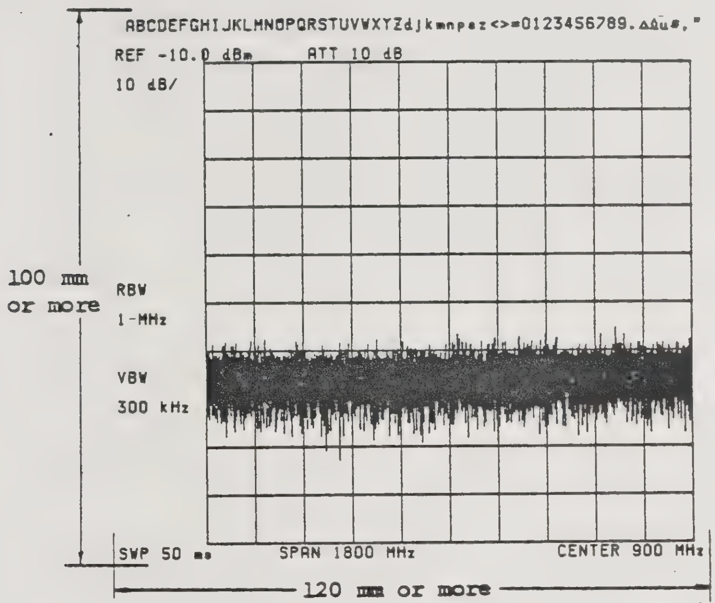


Fig. 12-4 Display area

12-3-6. CRT Raster and Orthogonality Distortion

Specification: Less than ± 1 mm

(1) While the instrument is in the initial state, check the raster edges against the graticule either visually or with a scale.

(2) Check to make sure that the barrel or pincushion distortion, if any, is less than 1 mm with respect to the standard pattern scale included in the maintenance kit.

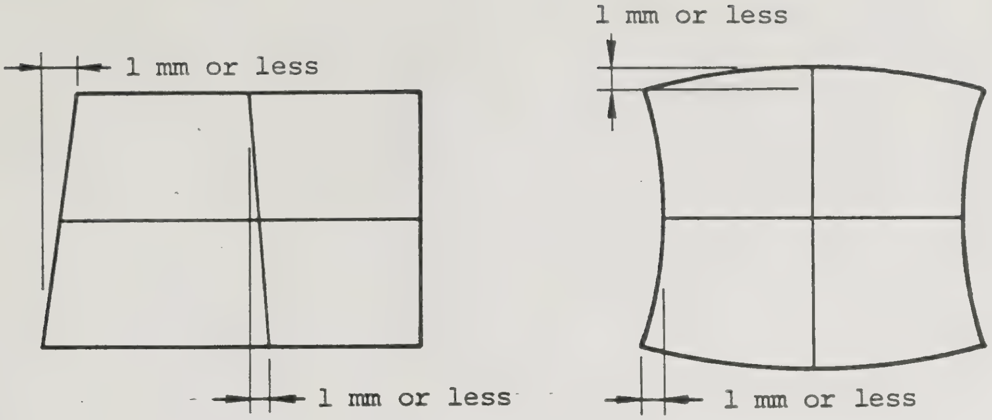
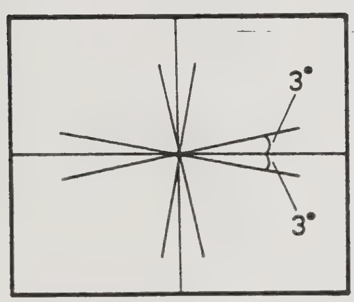


Fig. 12-5 CRT raster and orthogonality distortion

12-3-7. Trace Align

Specification: Variable over ±3 degrees or more.

(1) While the instrument is in the initial state, check graticule either visually or with a scale.



* 3 degrees can be obtained by a gradient of 3 mm in 57 mm as shown below.

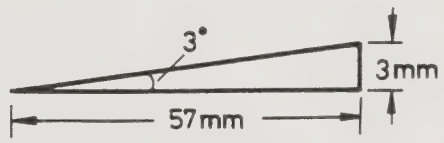


Fig. 12-6 Trace align

(2) After adjusting trace rotation to the normal state, check to make sure that it is variable over ±3 degrees. The location of the adjustment is shown below:

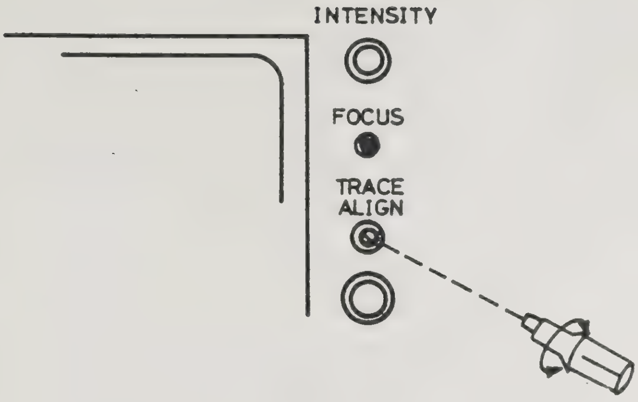


Fig. 12-7 Trace align adjustment

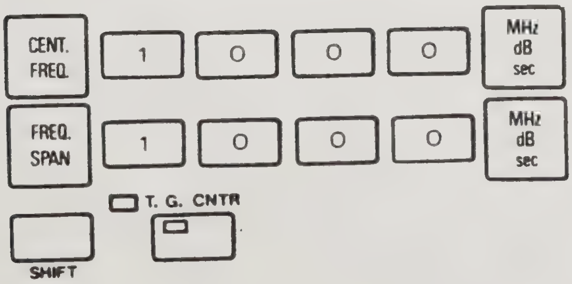
12-3-8. Intensity and Focus Alignment

Turn the INTENSITY control fully counterclockwise to make sure that the screen is completely blacked out. Gradually turn it clockwise and make sure that the display information starts dimly comes on when the control is around its center, and that display information can be observed at the maximum intensity but with no blur when the control is turned to the maximum (fully clockwise). Next, turn the FOCUS screwdriver adjustment to make sure that a correct and even focus is obtained over the entire screen.

12-3-9. Frequency Span Accuracy

Specification: Less than ±3% when frequency span > 500kHz
Less than ±5% when frequency span ≦ 500kHz

(1) While the instrument is in the initial state, set it up as follows:



(2) Next, press [⇧] to position the marker to the rightmost graticule. Press [ ] and then [⇩] to position the marker all the way to the leftmost graticule. The absolute value of the delta (Δ) marker frequency readout obtained at that time indicates the actual frequency span, which should be within 1000 MHz ±30 MHz (±3%). The YTO main tune accuracy can be known from this frequency span.

(3) Press [FREQ. SPAN] [1] [0] [MHz dB sec] [ ]. An active marker is located on the leftmost graticule. Press [⇧] to reposition the marker all the way to the rightmost graticule. Compare the delta (Δ) marker frequency readout obtained at that time with the frequency span setting (10 MHz), and make sure that the readout is within 10 MHz ±0.5 MHz (±5%). The YTO FM tune accuracy can be known from this readout.

(4) Press [FREQ. SPAN] [5] [0] [0] [kHz +dBm msec] [ ]. Then press [⇩] to position the marker to the leftmost graticule. Compare the delta (Δ) marker frequency readout obtained at that time with the frequency span setting (500 kHz), and make sure that the readout is within 500 kHz ±25 kHz (±5%). The accuracy of the 3rd local VCO (20 MHz) can be known from this result.

(5) Press [FREQ. SPAN] [5] [0] [kHz +dBm msec] [ ]. Then press [⇧] to reposition the marker to the rightmost graticule. Compare the delta (Δ) marker readout obtained at that time with the frequency span setting (50 kHz), and make sure that the readout is within 50 kHz ±2.5 kHz (±5%). The accuracy of the 3rd local VCO (2 MHz) can be known from this result.

12-3-10. Marker Readout Accuracy in the Normal and T.G. Counter Mode

Specification: Normal: Center frequency accuracy plus Accuracy of frequency span between marker and center frequency)

T.G. Counter: Center frequency accuracy

(1) While the instrument is in the initial state, set it up as follows:
Connect the CAL. OUT. connector to the INPUT-1 connector (both on the RF section), then enter the following data:

[CENT. FREQ.] [1] [0] [0] [0] [MHz dB sec]

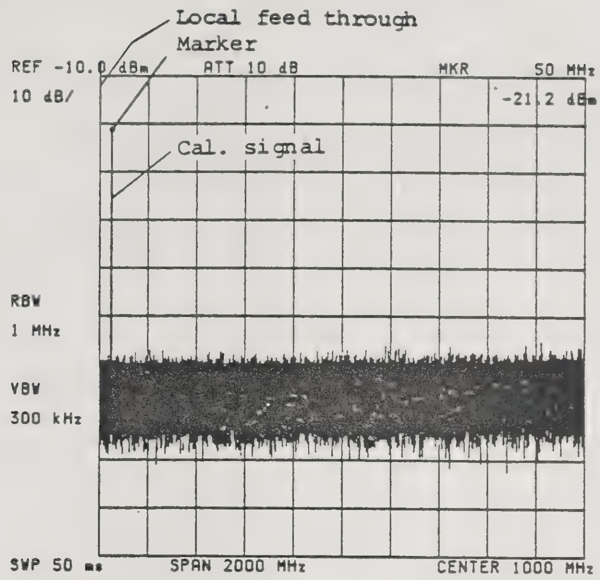
[FREQ. SPAN] [2] [0] [0] [0] [MHz dB sec]

[ ] MARKER

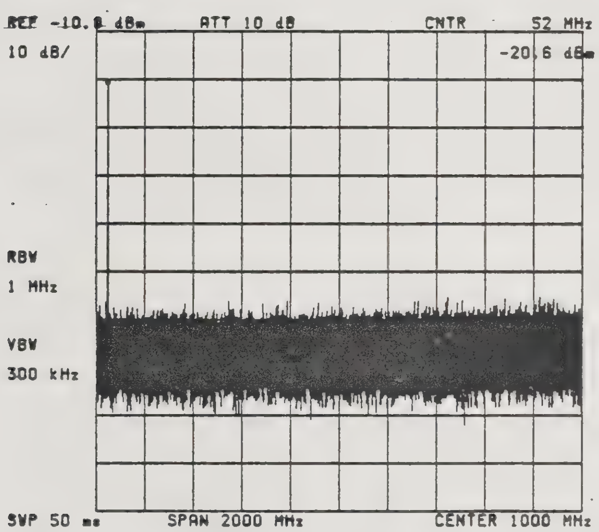
(2) Use [⇩] key and the DATA knob to position the marker to the peak of the CAL signal response. Read the marker frequency, and check to make sure that the readout is within the specification. The specification is: (center frequency accuracy) +(accuracy of frequency span between marker and center frequency), which is determined as 50 MHz ±(2000 MHz x $\frac{1}{100}$ +20 Hz) ±(1000 MHz - 50 MHz) x $\frac{3}{100}$ = 50 MHz ±48.5 MHz.

(3) Next, press [ ] SHIFT [ ] T. G. CNTR to switch the marker in the T.G. counter mode

(4) Position the marker to the peak of the CAL signal response. Read the marker frequency, and check to make sure that the readout is within the specification. The specification is the same as the center frequency accuracy, which is 50 MHz ±(2000 MHz x $\frac{1}{100}$ +20 Hz) = 50 MHz ±20 MHz.



(1) Normal Marker Mode



(2) T.G. Counter Mode

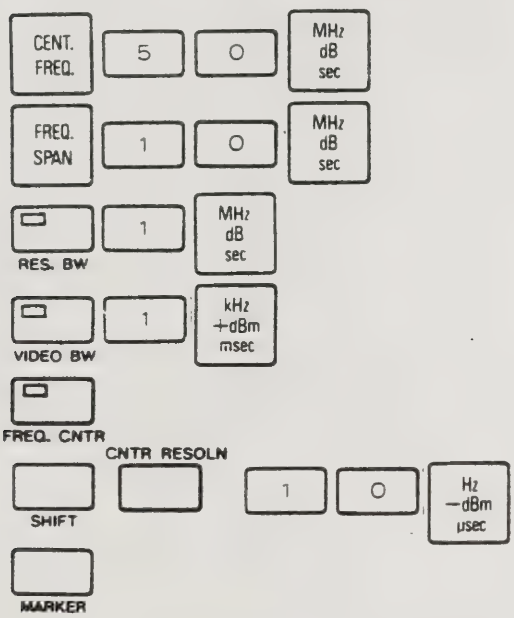
Fig. 12-8 Marker readout accuracy in the Normal and T.G. Counter modes

12-3-11. Marker Readout Accuracy in the Counter Mode

Specification: Master oscillator accuracy x readout frequency ± 2 counts when counting a spectrum frequency whose level is more than 25 dB above the average noise level.

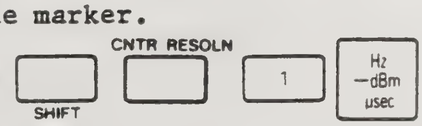
(1) While the instrument is in the initial state, set it up as follows:

Connect the CAL. OUT. connector to the INPUT-1 connector, then key in the following data:



(2) Check to make sure that a marker frequency readout of 50.00000 MHz is obtained on the display when a signal response of more than 25 dB above the average noise level is indicated by the marker.

(3) Press



to set counter resolution to 1 Hz. If the readout is 50.000000 MHz, the tuned amplifier operation is assumed to be normal.

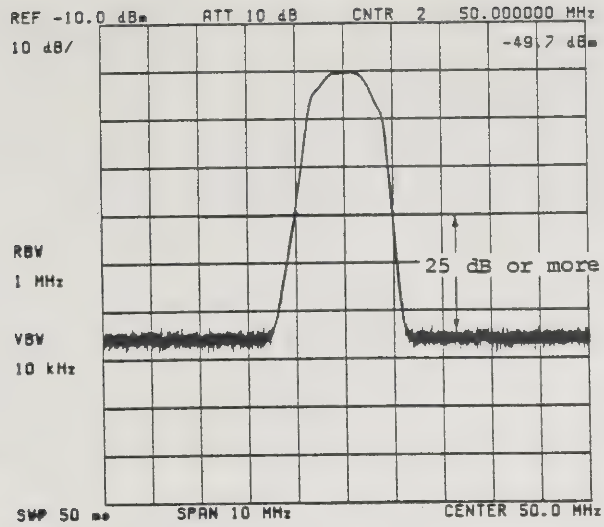


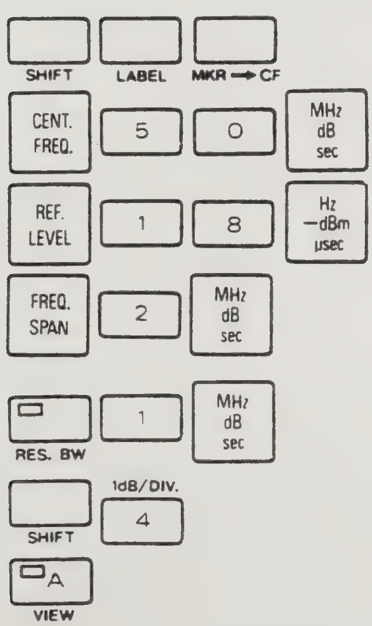
Fig. 12-9 Marker readout accuracy in the Counter mode

12-3-12. Resolution Bandwidth Accuracy

Specification: Within ±20% of each resolution bandwidth.

(1) While the instrument is in the initial state, set it up as follows:

Connect the CAL. OUT. connector to the INPUT-1 connector, then type in the following:



(Executes the error correction routine.)

(Stores the signal response trace.)

(2) Press [PEAK SEARCH] to indicate the peak with the marker. Then press [Δ] and reposition the marker to the Δ = −3 dB point on either side of the peak. Press [Δ] again and reposition the marker to the other Δ = −3 dB point on the opposite side of the peak.

The delta (Δ) marker frequency readout obtained at that time indicates the 3 dB bandwidth. Check to make sure that the bandwidth is within the 800 kHz to 1.2 MHz specification.

(3) Check the 3 dB bandwidths at each resolution bandwidth and frequency span selected with [FREQ. SPAN] and [RES. BW] keys. The resolution bandwidths, optimum frequency spans, and corresponding 3 dB bandwidth specifications are listed in the following table:

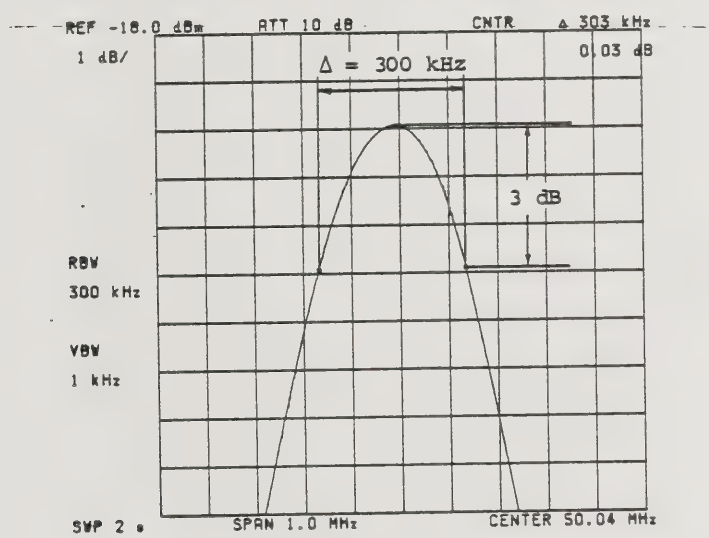


Fig. 12-10 Resolution Bandwidth Check

Table 12-3 Resolution bandwidths and optimum frequency spans

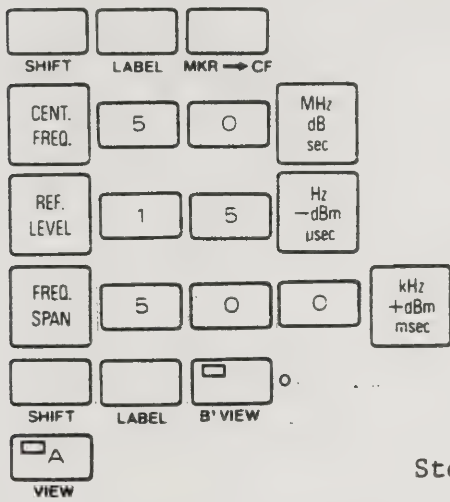
RES. BW	SPAN	Specification
1 MHz	2 MHz	800 kHz to 1.2 MHz
300 kHz	1 MHz	240 kHz to 360 kHz
100 kHz	200 kHz	80 kHz to 120 kHz
30 kHz	100 kHz	24 kHz to 36 kHz
10 kHz	20 kHz	8 kHz to 12 kHz
3 kHz	10 kHz	2.4 kHz to 3.6 kHz
1 kHz	2 kHz	800 Hz to 1.2 kHz
300 Hz	1 kHz	240 Hz to 360 Hz
100 Hz	200 Hz	80 Hz to 120 Hz
30 Hz	100 Hz	24 Hz to 36 Hz
10 Hz	100 Hz	8 Hz to 12 Hz

* For the resolution bandwidth accuracy check described in paragraphs 12-3-11 and 12-3-12, the vertical axis accuracy for 1 dB/div. and 10 dB/div. and the frequency span accuracy on the horizontal axis are both assumed to be calibrated to error zero. However, slight error in these axes wont'd raise any serious problems when performing the specification comformity check. For a more precision check, first calibrate the vertical scale for 1 dB/div. and 10 dB/div. according to paragraph 12-4-1, and use the delta marker in the T.G. Counter mode for frequency span measurement on the horizontal scale.

12-3-13. Resolution Bandwidth Accuracy for QP Measurement (with the QP Option only)

Specification: 6 dB bandwidth: 120 kHz ±20 kHz
9 kHz ±1 kHz
200 Hz ±20 Hz

(1) For the instrument with the QP Option, press MASTER RESET to return the instrument into the initial default state after the above resolution bandwidth check over 1 MHz through 10 Hz has been completed. Then set up the instrument for the following: Connect the CAL. OUT. connector to the INPUT-1 connector, then enter as follows:



(Error collection routine)

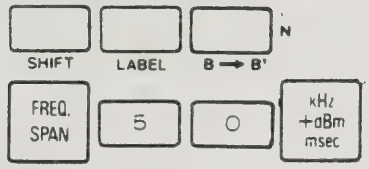
(QP MODE BW 120 kHz check)

Store the wave form. (freeze the trace)

(2) Now press PEAK SEARCH to capture the signal response peak. Then press Δ and position the marker to the Δ = -6 dB point on one side of the peak. Press Δ again and position the marker to the other -6 dB point on the opposite side of the peak, where Δ =0 dB. The delta marker readout at that time indicates the 6 dB bandwidth. Verify that it is within the specification.

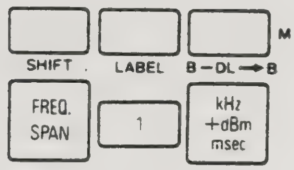
(3) Similarly check the 9 kHz and 200 Hz bandwidths as well. The panel setup and optimum frequency spans for the 9 kHz and 200 Hz bandwidth check are shown in the following:

• For 9 kHz bandwidth:



(QP MODE BW 9 kHz)

• For 200 Hz bandwidth:



(QP MODE BW 200 Hz)

If the QP mode bandwidth check mode is selected (e.g. by pressing 

o) for the TR4172 Analyzer with no QP Option, the actual bandwidth won't be set up although message "QP BW CHECK" will be shown on the display.

12-3-14. Resolution Bandwidth Selectivity (60/3 dB bandwidth ratio)

Specification: Less than 10:1 at 1 MHz and 300 kHz.
Less than 13:1 over 100 kHz to 10 Hz.

(1) While the instrument is in the initial default state, set it up as follows:

Connect the CAL. OUT. connector to the INPUT-1 connector, then key in as follows:

[SHIFT] [LABEL] [MKR → CF] (Executes the error correction routine.)

[CENT. FREQ.] [5] [0] [MHz dB sec]

[FREQ. SPAN] [1] [0] [MHz dB sec]

[RES. BW] [1] [MHz dB sec]

[VIDEO BW] [3] [kHz +dBm msec]

[INPUT ATT.] [0] [MHz dB sec]

[PEAK SEARCH] [MKR → CF]

[VIEW A] (Stores the signal response trace.)

(2) Press [Δ] and position the marker to Δ = -60 dB point on either side of the signal peak. Press [Δ] again and reposition the marker to the other -60 dB point on the opposite side of the signal peak where Δ = 0 dB. The delta (Δ) marker frequency readout obtained at that time indicates the 60 dB bandwidth. Check to make sure that this bandwidth is less than 10 MHz (10:1).

(3) Check the selectivities at each frequency span, resolution bandwidth, and video bandwidth sequentially selected with [FREQ. SPAN], [RES. BW], and [VIDEO BW] keys. Table 12-4 shows resolution bandwidths, optimum frequency spans and video bandwidths, and corresponding selectivity specifications.

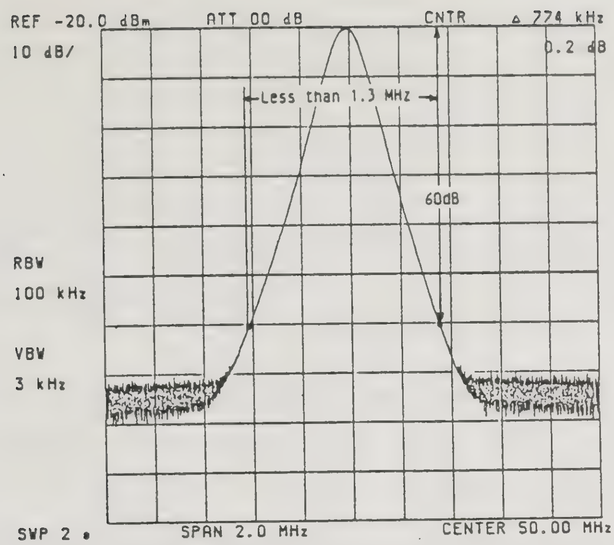


Fig. 12-11 Resolution Bandwidth Selectivity Test

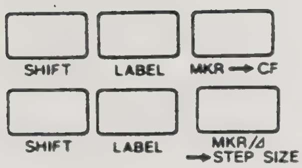
Table 12-4

RES. BW	SPAN	VIDEO BW	Specification
1 MHz	10 MHz	3 kHz	below 10 MHz
300 kHz	5 MHz	3 kHz	below 3 MHz
100 kHz	2 MHz	3 kHz	below 1.3 MHz
30 kHz	500 kHz	3 kHz	below 390 kHz
10 kHz	200 kHz	1 kHz	below 130 kHz
3 kHz	50 kHz	300 Hz	below 39 kHz
1 kHz	20 kHz	300 Hz	below 13 kHz
300 Hz	5 kHz	100 Hz	below 3.9 kHz
100 Hz	2 kHz	30 Hz	below 1.3 kHz
30 Hz	500 Hz	10 Hz	below 390 Hz
10 Hz	200 Hz	3 Hz	below 130 Hz

12-3-15. Resolution Bandwidth Switching Level Accuracy

Specification: Within ±1.0 dB with respect to the resolution bandwidth of 300 kHz before subject to error correction.

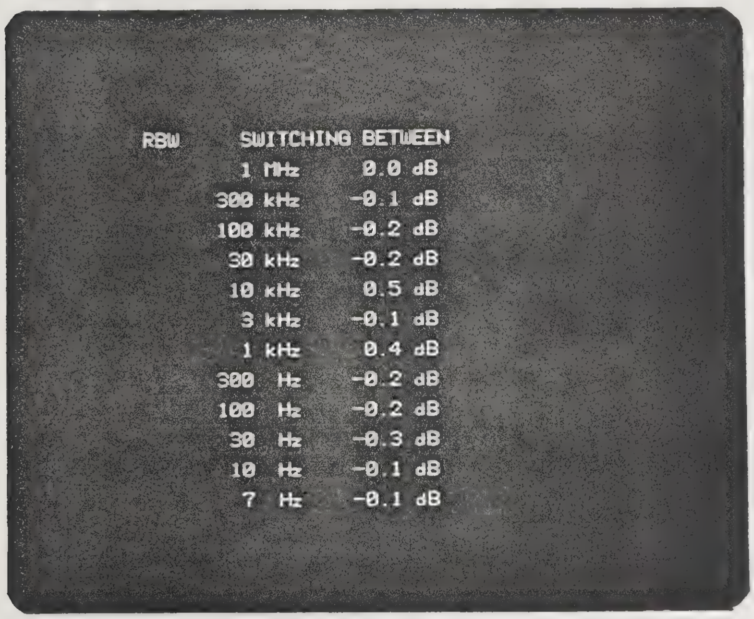
(1) While the instrument is in the initial default state, set it up as follows:
Connect the CAL. OUT. connector to the INPUT-1 connector, and key in as follows:



(Executes the error correction routine.)

(Lists the correction data.)

(2) Check to make sure that the level deviations at each resolution bandwidth is within 1.0 dB with respect to the level correction data at the resolution bandwidth of 300 kHz.



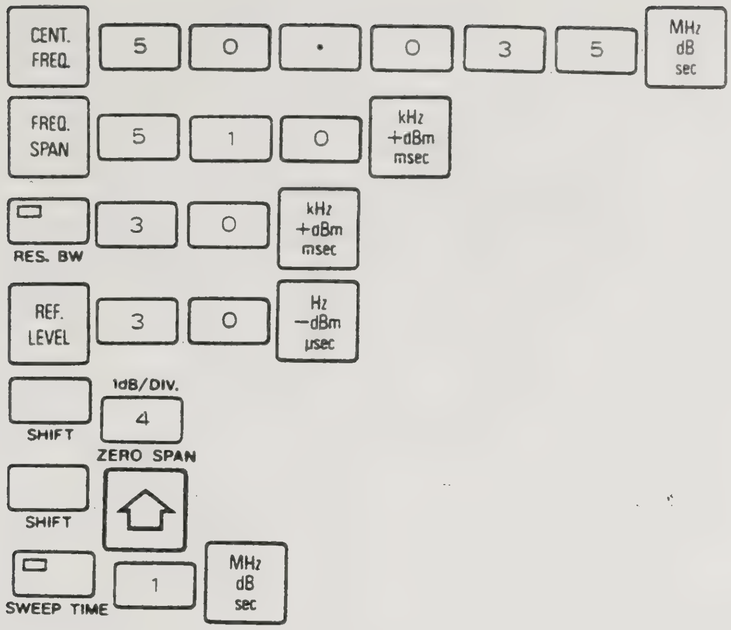
RBW	SWITCHING BETWEEN
1 MHz	0.0 dB
300 kHz	-0.1 dB
100 kHz	-0.2 dB
30 kHz	-0.2 dB
10 kHz	0.5 dB
3 kHz	-0.1 dB
1 kHz	0.4 dB
300 Hz	-0.2 dB
100 Hz	-0.2 dB
30 Hz	-0.3 dB
10 Hz	-0.1 dB
7 Hz	-0.1 dB

Fig. 12-12 Level correction data listing

12-3-16. Residual FM Component

Specification: 8 kHzp-p/sec. When frequency span $\geq$ 510 kHz
2 Hzp-p/sec. When frequency span $<$ 50 kHz

(1) While the instrument is in the initial default state, set it up as follows:
Connect the CAL. OUT. connector to the INPUT-1 connector, then key in as follows:



(2) The above setup activates an internal slope detection network using IF filters, which allows for observation of the residual FM component while the 1st local oscillator is unlocked. Read the frequency variation in one second from the response shown on the display, while bearing in mind that the vertical scale is 2 kHz/dB at a resolution bandwidth of 30 kHz. If the signal response trace out-scales begin to drift, etc., press [CENT. FREQ.] again and reposition the response in the center of the scale with the DATA knob.

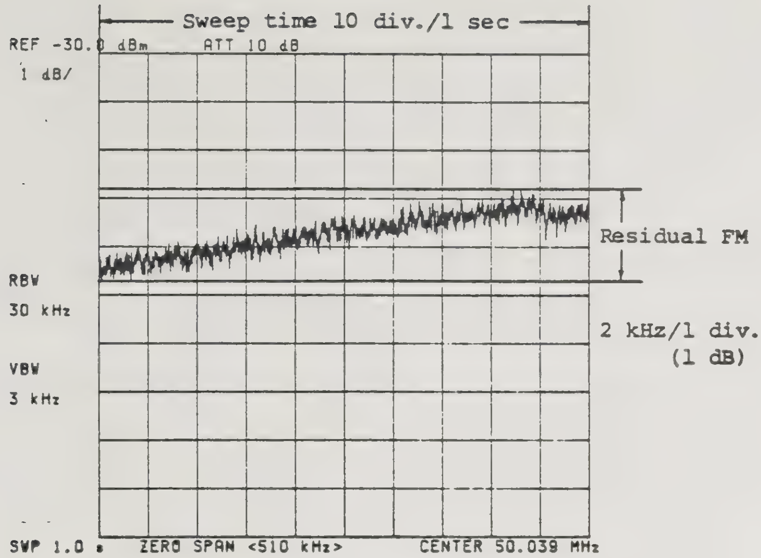
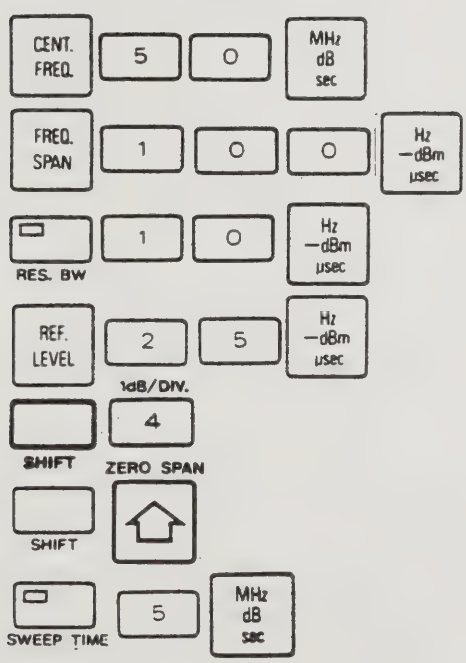


Fig. 12-13 Residual FM when the 1st local unlocked

(3) Press MASTER RESET to return the instrument into the initial default state, then set it up as follows:
Connect the CAL. OUT. connector to the INPUT-1 connector, then key in the following:



(4) The above setup activates the internal slope detection network using IF filters, which allows for observation of the residual FM component contained in the 2 MHz 3rd local VCO output. Read the frequency variation in one second (2 divisions on the horizontal axis) from the signal response on the vertical scale, while bearing in mind that the vertical scale is 1 Hz/dB at a resolution bandwidth of 10 Hz. If the signal response trace out-scales due to drift, etc, press [CENT. FREQ.] again and reposition the response in the center of the scale with the DATA knob.

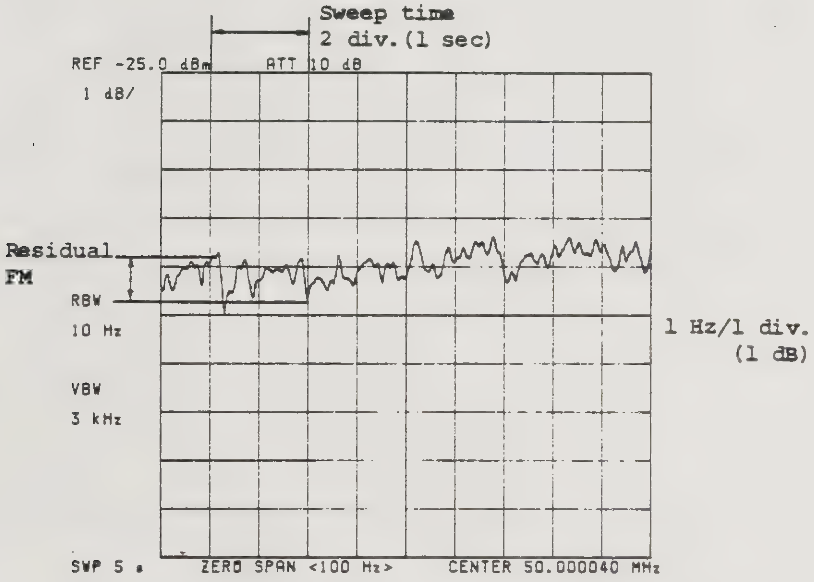


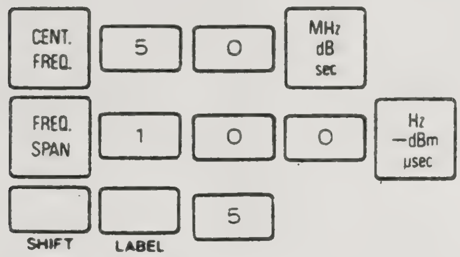
Fig. 12-14 Residual FM of the 3rd local 2 MHz VCO

12-3-17. Frequency Stability

Specification: 30 Hz p-p/min. when frequency span < 50 kHz (at a constant temperature after one hour of warm-up)

(1) While the instrument is in the initial default condition, set it up as follows:

Connect the CAL. OUT. connector to the INPUT-1 connector, then key in as follows:



(Cuts off the routine that corrects the center frequency for each sweep.)

(2) Press [PEAK SEARCH] [Δ] and wait for one minute (12 sweep interval because a sweep time of 5 is selected in the above setup).

Press [PEAK SEARCH] again, which will show a frequency drift occurred in one minute, in the form of a delta (Δ) marker frequency.

Check to make sure that the frequency drift is less than 30 Hz/min.

12-3-18. Noise Sideband

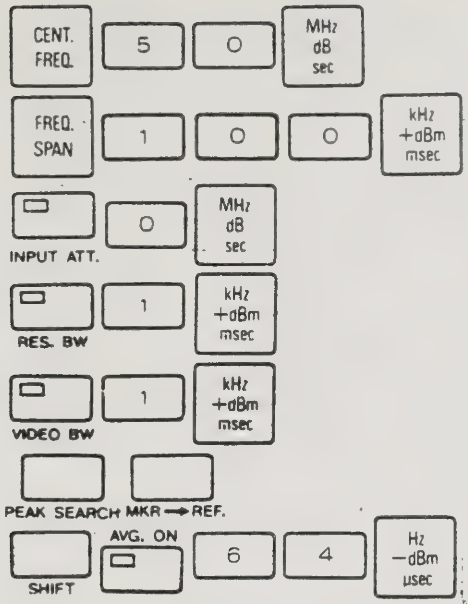
Specification: Less than -80 dB/1 kHz BW at 30 kHz apart from the carrier

Less than -75 dB/1 kHz BW at 20 kHz apart from the carrier

(where video bandwidth: 1 Hz, resolution bandwidth: 1 kHz)

(1) While the instrument is in the initial default state, set it up as follows:

Connect the CAL. OUT. connector to the INPUT-1 connector, then key in as follows:



(Sets up the number of averages to 64.)

(2) After 64 repetitions of averaging are completed, press [A] (VIEW) to store the resulting signal response. Press [PEAK SEARCH] [Δ], then use [⇧] [⇩] to read the average noise leves at $\Delta f = \pm 20$ kHz and $\Delta f = \pm 30$ kHz apart from the carrier peak, from the delta marker readout. These levels are sideband noise levels. Check to make sure that they are less than -75 dB and -80 dB respectively.

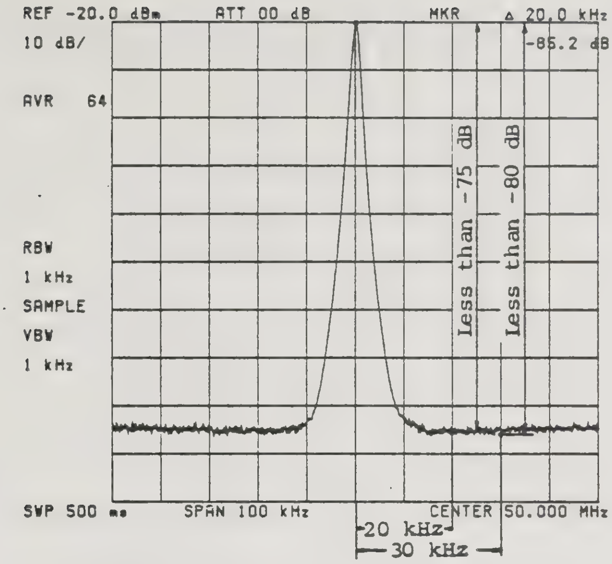


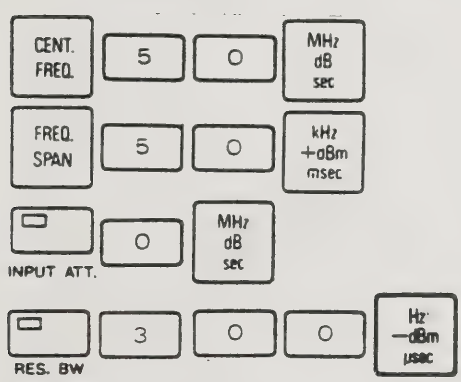
Fig. 12-15 Noise sideband

12-3-19. Adjacent Spurious

Specification: 70 dB (below carrier level)

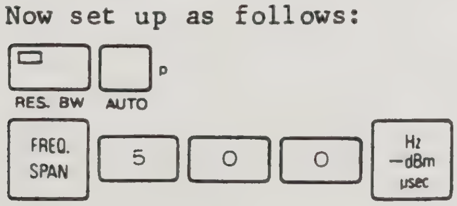
(1) While the instrument is in the initial default state, set it up as follows:

Connect the CAL. OUT. connector the INPUT-1 connector, then key in as follows:

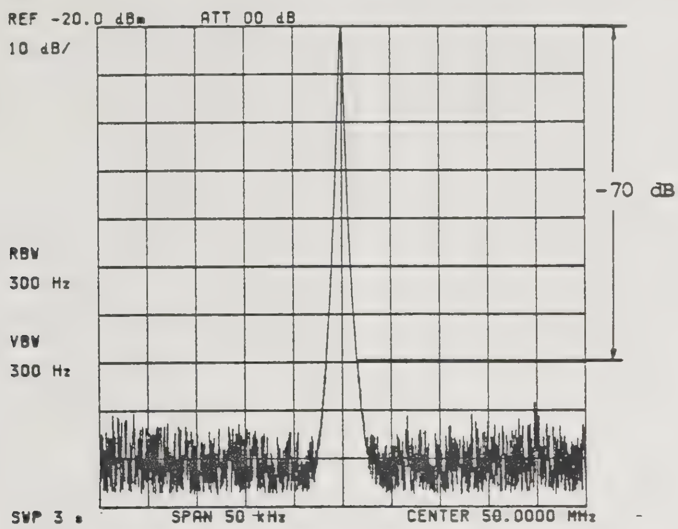


(2) Check to make sure that no spurious response exists within -70 dB from the carrier peak level.

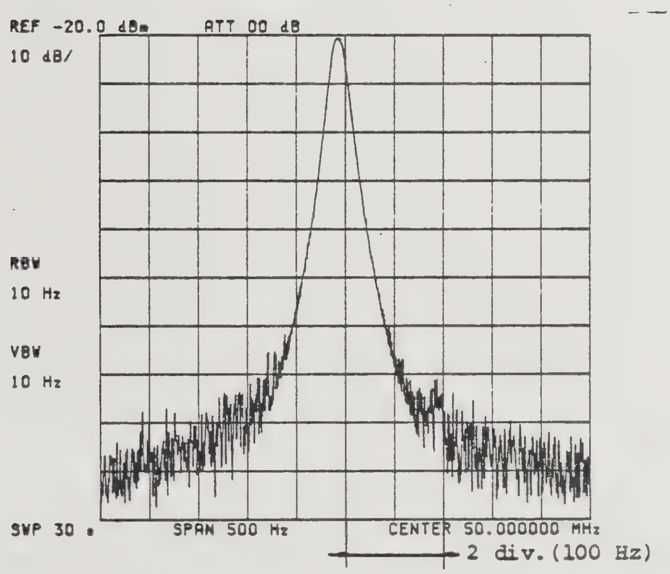
(3) Now set up as follows:



(4) Check to make sure that the spurious response at 100 Hz or more apart from the carrier peak is less than -70 dB in its level.



(1)



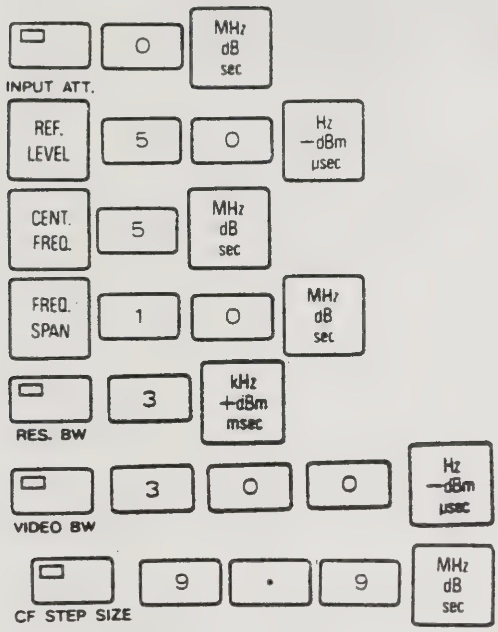
(2)

Fig. 12-16 Adjacent spurious

12-3-20. Residual Response

Specification: Not more than -100 dBm (with input ATT set at 0 dB, and no input signal applied)

(1) While the instrument is in the initial default state, set it up as follows:



(2) Check again to make sure that no input signal or connector is coupled to the input of the instrument.

(3) Press CENT. FREQ. . There after each time  is pressed, the center frequency will increase 9.9 MHz steps. Check to make sure that no residual response with its level exceeding -100 dBm exists between 0 and 1800 MHz.

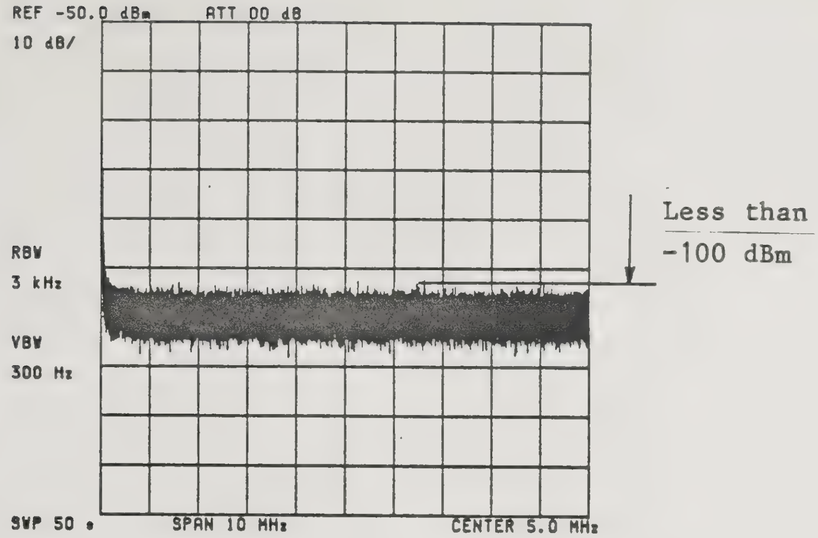


Fig. 12-17 Residual response

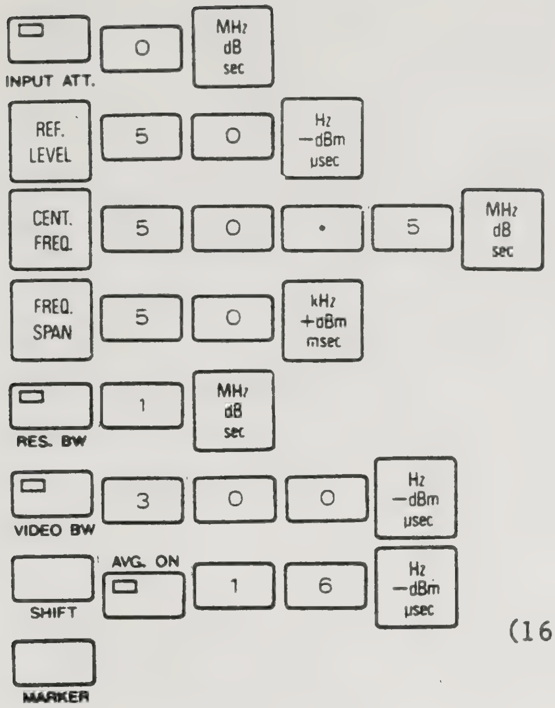
12-3-21. Noise Level

Specification: -80 dBm at resolution BW of 1 MHz and video BW of 1 Hz.
-85 dBm at resolution BW of 300 kHz and video BW of 1 Hz.
-100 dBm at resolution BW of 10 MHz and video BW of 1 Hz.
-105 dBm at resolution BW of 3 kHz and video BW of 1 Hz.
-130 dBm at resolution BW of 10 Hz and video BW of 1 Hz.
(Center frequency > 1 MHz)

(1) While the instrument is in the initial default state, set it up as follows:
Connect the CAL. OUT. connector to the INPUT-1 connector, then enter the following:

SHIFT LABEL MKR→CF W (Executes the error correction routine.)

Disconnect the CAL. OUT. signal cable and cable adapter from the INPUT-1 connector, then enter as follows:



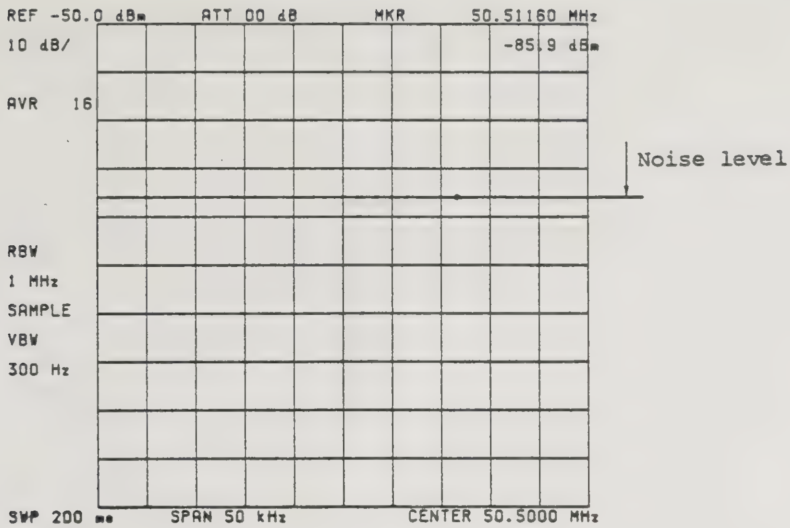
(16 repetitions of averaging)

(2) Read the marker level and check to make sure that the level meets the noise level specification (below -80 dBm) at resolution bandwidth of 1 MHz. After completing checking, press SHIFT AVG. OFF to clear the Averaging mode.

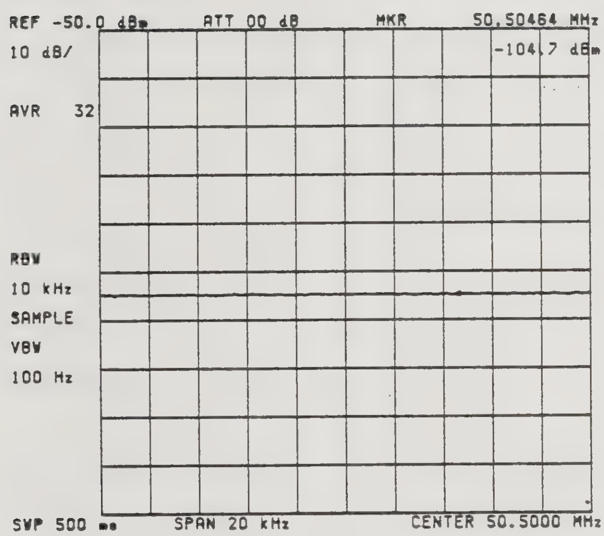
(3) Similarly, check the noise levels at each resolution bandwidth. The optimum setup values are listed in Table 12-5. If slight peaks and dips remain in the signal response after averaging, slightly move the marker and read an averaged level.

Table 12-5

RES. BW	1 MHz	300 kHz	10 kHz	3kHz	10 Hz
FREQ. SPAN	50 kHz	50 kHz	20 kHz	20 kHz	100 Hz
VIDEP BW	300 Hz	300 Hz	100 Hz	30 Hz	10 Hz
No. of AVG	16	16	32	32	32



(1)



(2)

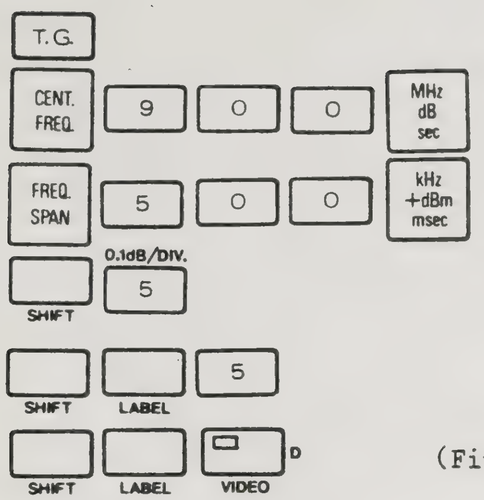
Fig. 12-18 Noise Level

12-3-22. Fine Tune Level Deviation

Specification: Less than 0.5 dB p-p

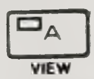
(1) While the instrument is in the initial default state, set it up as follows:

Connect the TRACKING GENERATOR OUTPUT connector to the INPUT-1 connector with a BNC-BNC cable, then enter as follows:

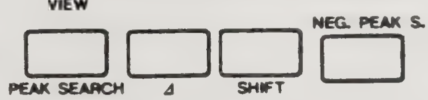


(Fine Tune flatness check mode)

(2) Next, change the reference level until the TG signal response is observed on the display.

(3) Press 

to store the signal response.

(4) Press 

to read the difference between the maximum and minimum levels of the TG signal response by means of he delta marker. Check to make sure that the difference is less than 0.5 dB.

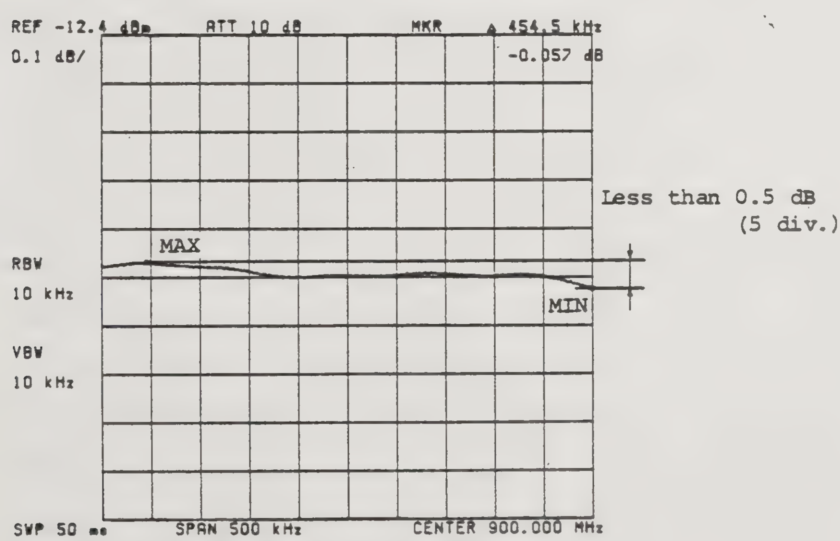
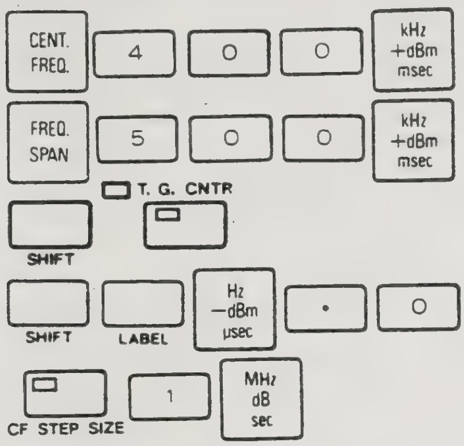


Fig. 12-19 Fine Tune level deviation

12-3-23. Counter Operation (Operating Frequency)

Specification: Operating frequency 400 kHz to 1500 MHz

(1) While the instrument is in the initial default state, set it up as follows:



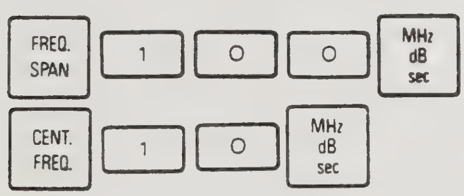
(Directly counts TG frequency.)

(2) Check to make sure that the counter is normally counting, with its readout digits indicating constant numbers (except for the 100 Hz digit which may be flickering).

(3) Press 

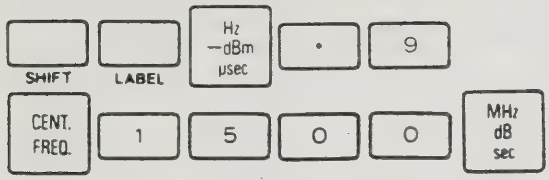
, then use  to set the center frequency to 10.4 MHz (at 1 MHz stepping). Check to make sure that the then counter reading is identical to the center frequency readout (with an allowance of 1% of the frequency span).

(4) Now enter the following:



(5) By turning the DATA knob slowly, sweep the center frequency from 10 MHz through 1500 MHz, and check to make sure that the counter reading is identical to the center frequency readout (with an allowance of 1% of the frequency span) over the entire sweep span.

(6) Now enter as follows:



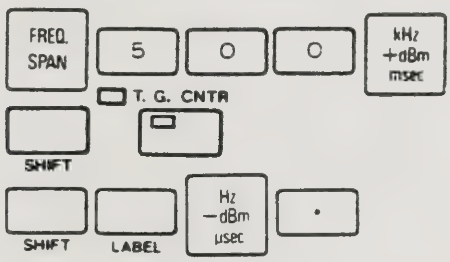
(Counter Auto mode)

(7) By slowly turning the DATA knob, sweep the center frequency from 1500 MHz through 1800 MHz, and check to make sure that the counter normally counts over the entire sweep span.

12-3-24. Counter Operation (Local Frequency Counting)

Specification: Should normally count each local frequency.

(1) While the instrument is in the initial default state, set it up as follows:



(2) Sequentially press numeric dat keys ([0] through [9]) to select the tracking generator output and local frequency count modes. Check to make sure that the following specifications are satisfied in each of these modes:

[0] : Count Point TG
Directly counts the TG output frequency identified by the marker. The Counter reading is identical to the center frequency readout, with an allowance of 1%,

[1] : Count Point 3RD LO 23M VCO
Shows the output frequency of the 3rd local VCO (23 MHz). The counter operation is assumed to be normal if all the digits other than the LSD (which may be flickering) give a constant frequency readout over 22 to 24 MHz.

[2] : COUNT POINT 3RD LO 2M VCO

Shows the output frequency of the 3rd local VCO (2 MHz). The counter operation is assumed to be normal if all the digits other than LSD give a constant readout over 0.9 to 1.1 MHz.

[3] : COUNT POINT TG 200 M IF

Shows 0 MHz as this mode is currently not used.

[4] : COUNT POINT 1ST LO IF

Shows the IF frequency for the 1st local oscillator. It normally indicates a frequency below 50 MHz. When the frequency span setting is 500 kHz or below, the counter will show a frequency with no fractional part.

[5] : COUNT POINT 2ND LO 204M

Shows the IF frequency for the 2nd local oscillator. The counter operation is assumed to be normal if all the digits other than the LSD give a constant frequency readout at around 204 MHz.

[6] : COUNT POINT 3RD LO 153 M

Shows the 3rd local oscillator output of 153 MHz. The counter operation is assumed to be normal if all the digits other than the LSD give a constant frequency readout at around 153.3 MHz.

[7] : COUNT POINT 4TH LO 33 M

Shows the 4th local oscillator output of 33 MHz. The counter operation is assumed to be normal if all the digits other than the LSD give a constant frequency readout at around 33.3 MHz.

[8] : COUNT POINT 1ST LO

Shows the 1st local oscillator output frequency. It is not a direct count but a value determined from the 1st IF frequency. The counter operation is assumed to be normal if all digits above the 1 MHz order give a constant readout with no flicker.

9 : COUNT POINT AUTO

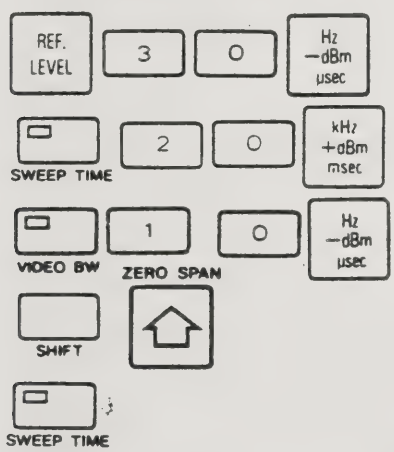
Normally counts the TG output frequency identified by the marker. In the frequency ranges which are beyond the counting capability of the counter (0-400 kHz and 1500-1800 MHz), the marker frequency is determined from each local frequency. The counter reading is the same as the center frequency readout, with an allowance of 1%.

12-3-25. Analog Sweep

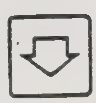
Specification: Error on the vertical axis: ±0.2 div. or less when sweep time is 19 ms.

Error on the horizontal axis: 0-0.5 div. at zero frequency span.

(1) While the instrument is in the initial default state, set it up as follows:



(An UNCAL message will be shown; ignore it.)

(2) Next, alternately press  and  to switch between analog sweep (10 ms) and digital sweep (20 ms).

(3) Check to make sure that the positional departure between the analog and digital traces is within the specification along both vertical and horizontal axes.

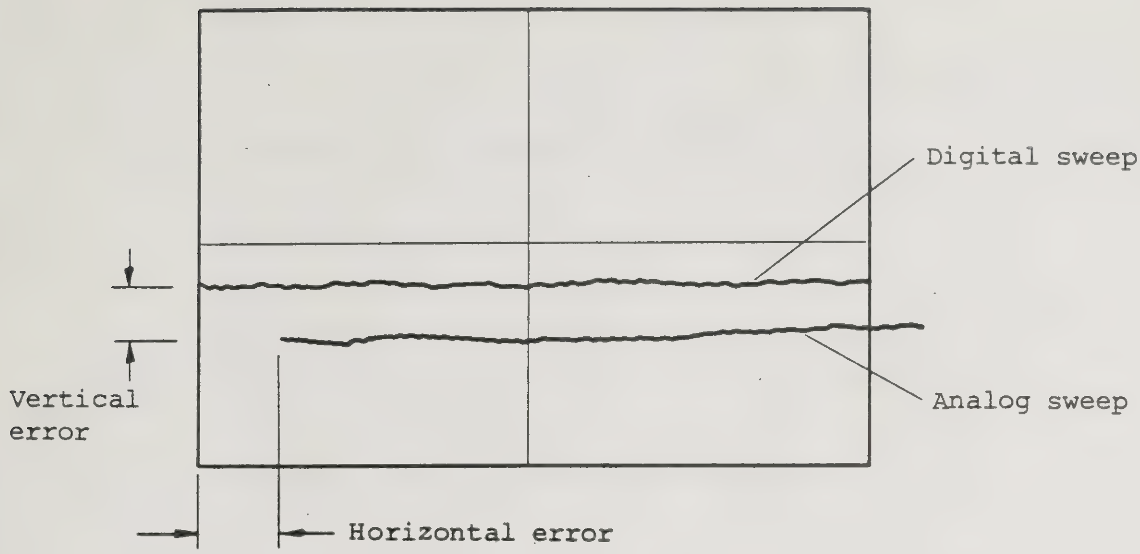
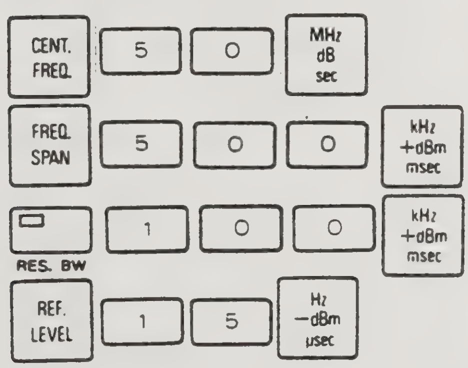


Fig. 12-20 Analog Digital Sweep Switching Error

12-3-26. Reference Level Variable Range

Specification: Should be variable over 4 dB p-p or more.

(1) While the instrument is in the initial default state, set it up as follows:
Connect the CAL. OUT. connector to the INPUT-1 connector, and enter as follows:



(2) Next, turn the screwdriver control marked CAL on the front panel fully counterclockwise. Press PEAK SEARCH, then read the signal level at that point.

(3) Then turn the CAL control fully clockwise. Press PEAK SEARCH, then read the signal level at that point. Check to make sure that the marker level readout has changed by more than 4 dB.

12-3-27. GP-IB Check

Check for the normal GP-IB functions by referring to SECTION 8 (GP-IB ATTACHMENT AND PROGRAMMING SUPPORT.)

12-3-28. Key Operation Check

Check for normal key operations (except for screwdriver controls) by referring to paragraph 3-3-1 Front Panel Description.

12-4. PREFORMANCE CHECK REQUIRING MEASURING INSTRUMENTS

12-4-1. Sweep Time

Specification: $\pm$5% over 20 ms to 1000 s

$\pm$5% over 100 µs to 1000 s (at zero frequency span)

Required instruments: Signal generator (SG) capable of frequency modulation

Stop watch

(1) While the instrument is in the initial default state, apply a 50 MHz signal modulated with a 1 kHz signal from a signal generator (SG) to the input of the instrument. Set up the SG output as follows:

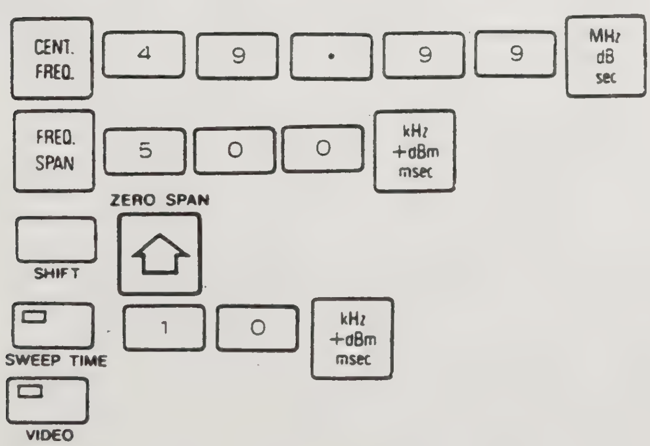
Carrier frequency: 50.00 MHz

Output level: -10 dBm

Modulation frequency: 1 kHz (AM)

Modulation depth: 10%

(2) Then set up the instrument as follows:



Adjust the TRIGGER LEVEL control until the signal trace stops on the display.

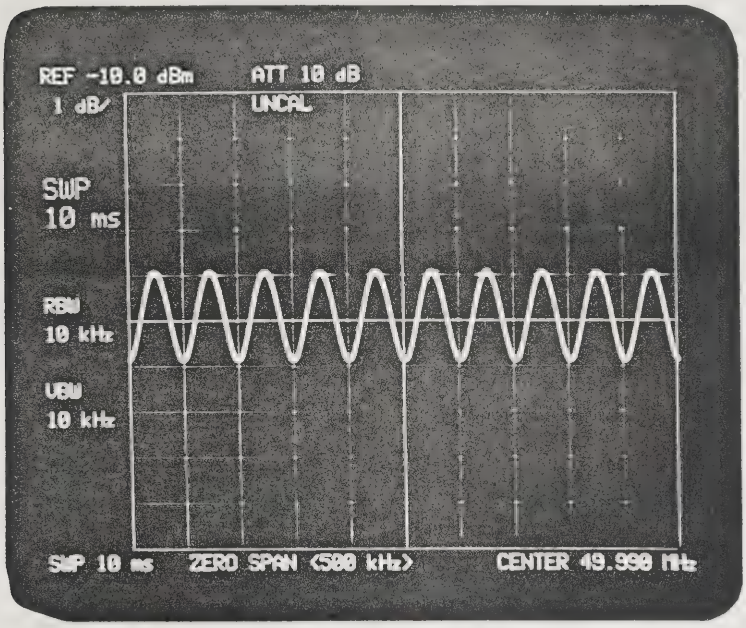


Fig. 12-21 Sweep time check

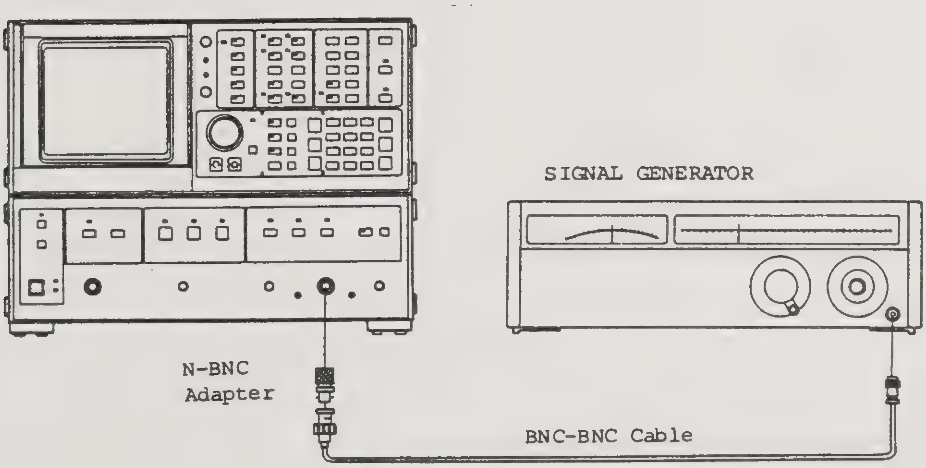


Fig. 12-22 Sweep time test setup

(3) Each division of the horizontal scale is assigned 1 ms as the sweep time is 10 ms. Since the 1 kHz signal has a period of 1 ms, the peaks or dips of the signal envelope should match each graticule on the screen. Visually check this point. The allowable deviation from the graticule is 0.5 div.

When using a stop watch:

(1) While the instrument is in the initial default state, set it up as follows:

[SWEEP TIME] [1] [0] [0] [MHz dB sec]

(2) Use the stop watch to measure the time required for a bright dot to sweep all the way from the leftmost to the rightmost graticule on the screen. Set the sweep time to 100 s, and check to make sure that the actual sweep time is 100 ±5 s.

12-4-2. Scan Trigger

Specification: Internal, Line, External, Video, Single

Video: Trigger point should be able to be variable over 1 division of the scale.

Single: Only one sweep should be triggered each time the key is operated.

Required instrument: Signal generator capable of frequency modulation.

(1) While the instrument is in the initial default state, set it up as follows:

[SWEEP TIME] [2] [0] [kHz +dBm msec]

(2) Press [LINE] to select the Line Trigger mode. The flashing frequency of the SWEEP IND. lamp will be lowered to indicate that the Line Trigger mode is selected.

(3) Next, press [EXT.] to select the External Trigger mode. Check to make sure that sweep is triggered each time the rear EXT. TRIG. connector is grounded (coupled with an earth potential).

(4) Press MASTER RESET to return the instrument into the initial default state. Apply a 50 MHz signal modulated with a 1 kHz signal from a signal generator (SG) to the input of the instrument. Set up the SG output as follows:

Frequency: 50.00 MHz

Output level: -10 dBm

Modulation frequency: 1 kHz

Modulation depth: 10%

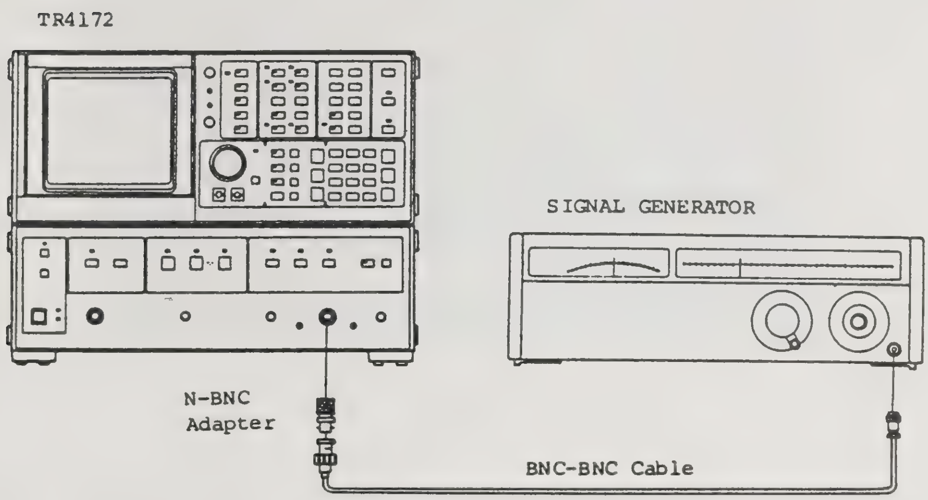
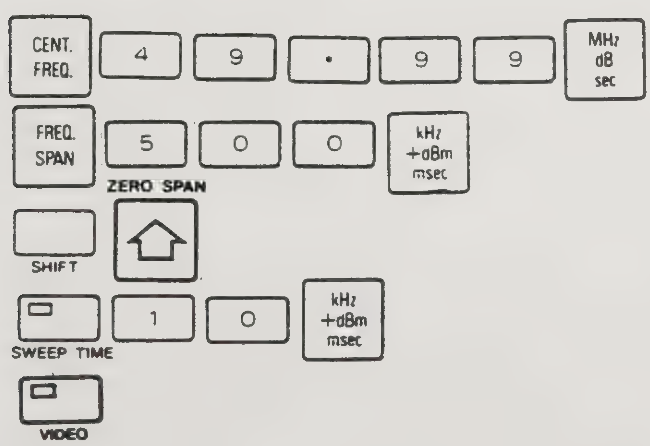


Fig. 12-23 Scan trigger test setup

(5) While the instrument is in the initial default state, set it up as follows:



(6) While watching the signal trace on the display, turn the TRIGGER LEVEL control to make sure that the trigger point is variable over at least one division of the display scale.

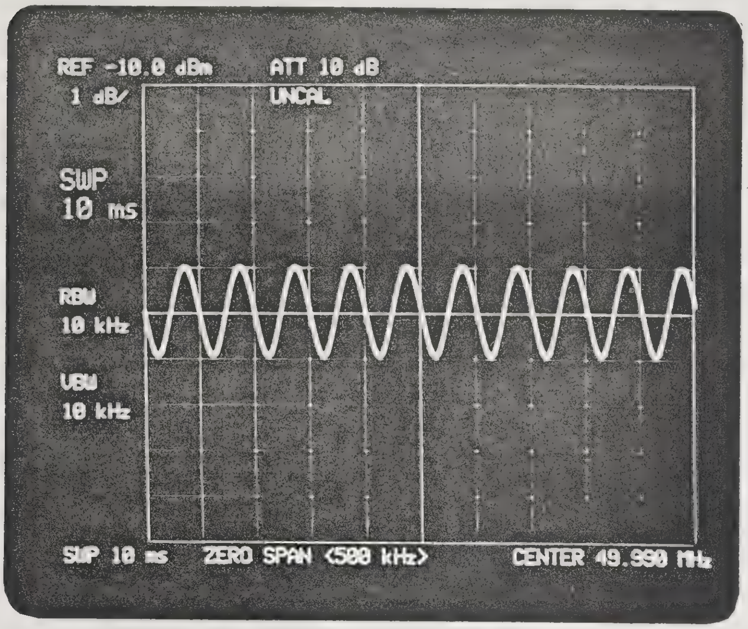


Fig. 12-24 Trigger level check

(7) Press 

to return the instrument into the initial default state. Check to make sure that only one sweep is triggered each time 

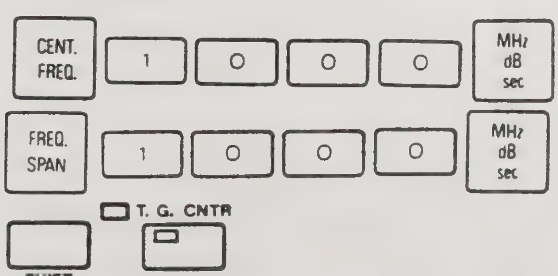
key is pressed.

12-4-3. Center Frequency Accuracy

Specification: ±(span x 1% ±20 Hz)

Required instrument: Synthesized signal generator

(1) While the instrument is in the initial default state, set it up as follows:



(2) Since the marker is located in the center of the scale, the marker frequency readout directly indicates the center frequency. Confirm that the readout is within 1000 MHz ±10 MHz The center frequency accuracy with broad frequency span setting can be known with the just described procedure. However, this technique (in which the internal counter is used for frequency measurement) is not adequate for measurement a frequency span setting of less than 10 kHz, where measurement is affected by tracking error of the tracking generator.

(3) If the synthesized signal generator has a reference time-base input, apply the REF. signal output from the INT. STD. OUTPUT connector (J4) of the instrument to this input, then press [SHIFT] [LABEL] [7] (INT. STD OUTPUT ON), and set up the SG output as follows. If the SG has no reference input, it may be used so far as its output frequency accuracy is 5×10^{-9} or less.

Output frequency: 1000 MHz

Output level: -20 dBm

(4) Connect the SG output to the input of the instrument.

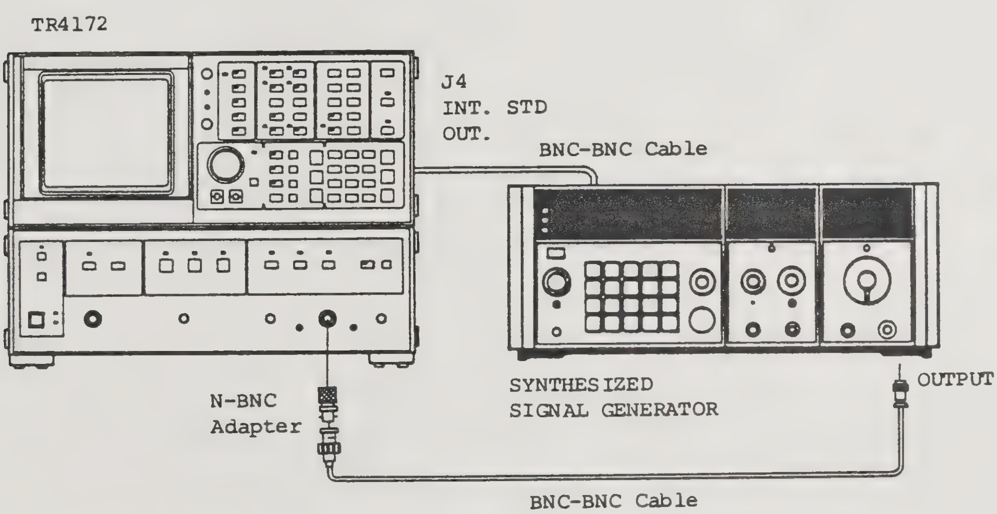


Fig. 12-25 Center frequency accuracy test setup

(5) Next, press [FREQ. SPAN] [1] [0] [0] [Hz −dBm μsec] to set the frequency span to 100 Hz.

(6) Confirm that the deviation of the input signal peak from the center graticule is less than ±21 Hz.

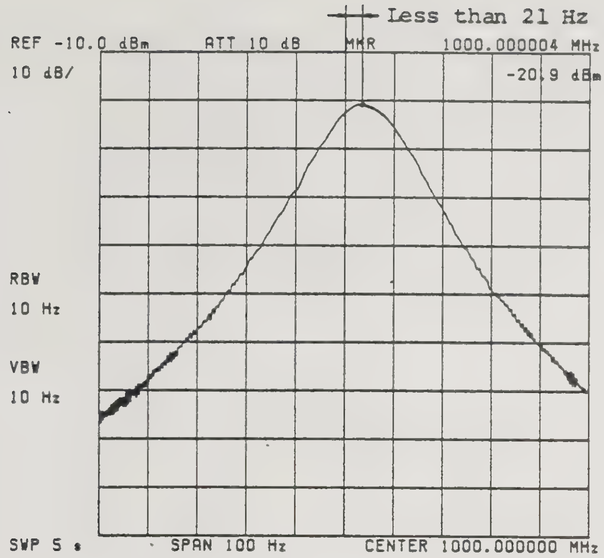


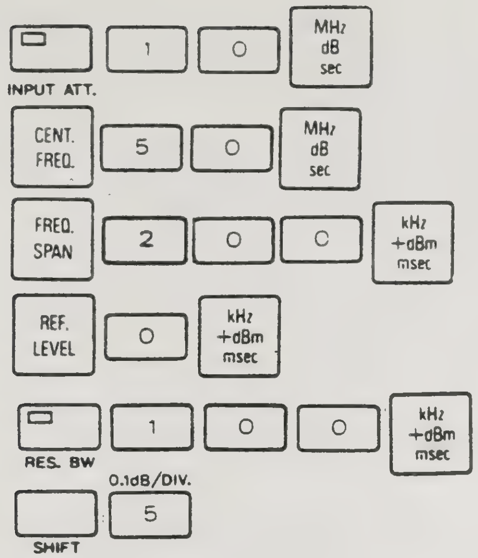
Fig. 12-26 Center frequency deviation

12-4-4. Vertical Scale Linearity (logarithmic scale)

Specification: ±0.02 dB/div. at 0.1 dB/div over 0 to 0.8 dB
±0.2 dB/div. at 1 dB/div. over 0 to 95 dB
±1 dB/div. at 10 dB/div. over 0 to 95 dB (20°C to 30°C)
±1.5 dB/div. at 10 dB/div. over 0 to 95 dB (0°C to 40°C)

Required instrument: External attenuators covering:
0 to 110 dB at 10 dB steps
0 to 11 dB at 1 dB step
0 to 1.1 dB at 0.1 dB step

(1) While the instrument is in the initial default state, set it up as follows:



(2) Apply a synthesized SG output of 50 MHz, 0 dBm to the input of the analyzer via an external attenuator. Set the attenuator to 0 dB attenuation. While slightly adjusting the SG output, position the signal response peak on the display to the top graticule.

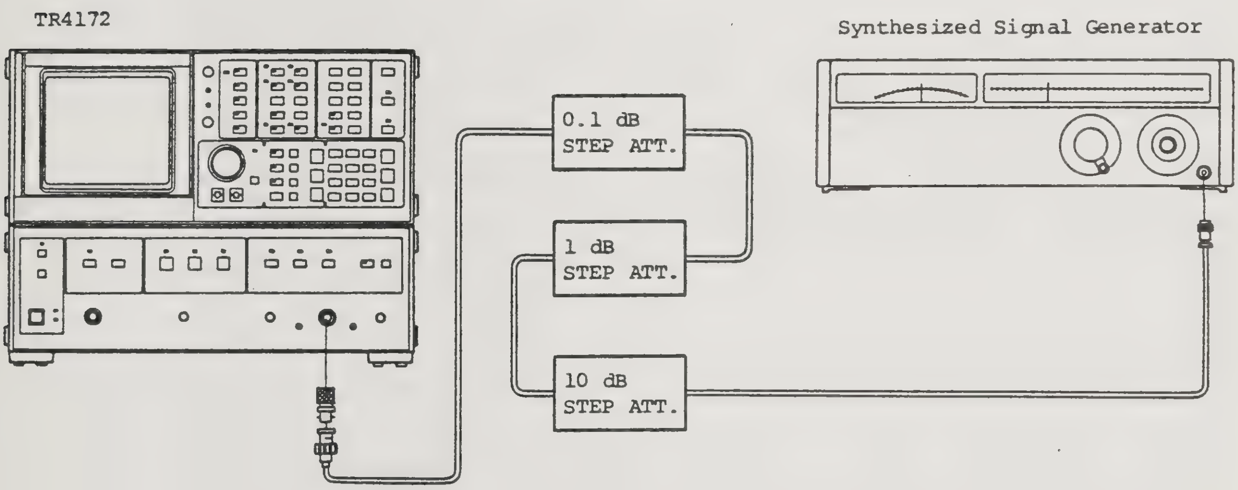


Fig. 12-27 Vertical scale linearity (log.) test setup

(3) Increase the attenuation of the external attenuator at 0.1 dB steps, confirm that each 0.1 dB increase in attenuation causes the signal peak on the display to be lowered 0.1 dB (1 div.) with an error of 0.02 dB (0.2 div.) each time.

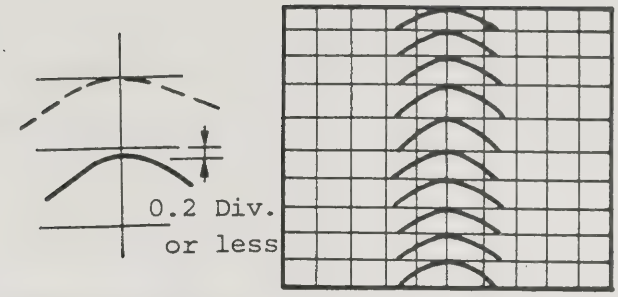


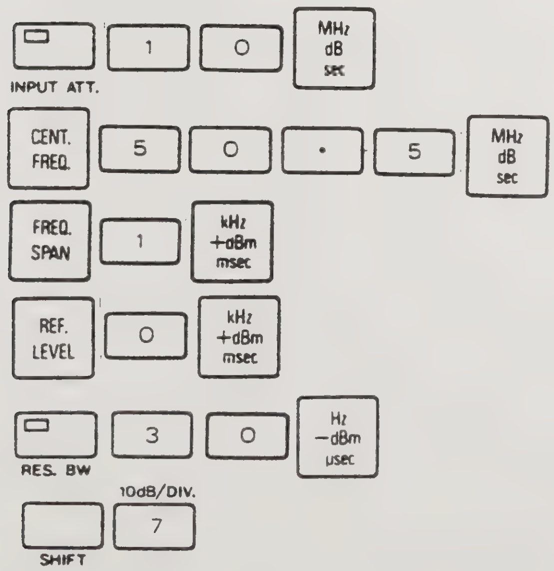
Fig. 12-28 Vertical scale linearity check

For accurate level identification, it is recommend to use [PEAK SEARCH] key each time the attenuation is increaseds.

(4) Then press [SHIFT] [4] (1dB/DIV.) to select a vertical scale factor of 1 dB/div. Set the external attenuator to 0 dB attenuation, then position the signal response peak to the top graticule on the display.

(5) While increasing the attenuation of the external attenuator by 1 dB steps, confirm that each 1 dB (1 div.) increase in attenuation causes the signal peak to be lowered one division (1 dB) with an error of ± 0.2 dB (± 0.2 div.) each time.

(6) Update the instrument setup as follows in temperature 20°C to 30°C:



(7) Set up SG output to 50.5 MHz, 0 dBm, and couple it to the input of the analyzer via the external attenuator. Set the attenuator to 0 dB attenuation. While slightly adjusting the SG output, position the signal response peak to the top graticule on the screen.

(8) While increasing the attenuation of the external attenuator from 0 to 90 dB at 10 dB steps, confirm that each 10 dB increase in attenuation causes the signal peak to be lowered by 10 dB (1 div.) with an error of ± 1 dB (0.1 div.) or less each time.

(9) Now set the external attenuator back to 0 dB attenuation. Slightly reduce the SG output level until the marker readout for the signal peak is -5 dBm.

(10) While increasing the attenuation of the external attenuator from 0 to 90 dB at 10 dB steps, confirm that each 10 dB increase in attenuation causes the signal peak to be lowered by 10 dB (1 div.) with an error of ± 1 dB (0.1 div.) each time.

(11) In a temperature range between $0^{\circ}C$ and $40^{\circ}C$, perform test steps (6) and below, and confirm that the signal peak error is within ± 1.5 dB.

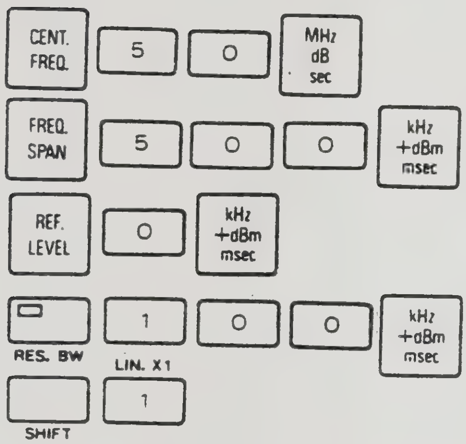
12-4-5. Vertical Scale Linearity (linear scale)

Specification: Within ±3% of the reference level

Required instruments: Signal generator

External attenuator covering 0 dB to 11 dB at 1 dB steps

(1) While the instrument is in the initial default state, set it up as follows:



(2) Apply as SG output of 50 MHz, 0 dBm to the input of the analyzer via an external attenuator. Set the external attenuator to 0 dB attenuation. While adjusting the SG output level, position the input signal response peak to the top graticule.

(3) Press PEAK SEARCH and record the marker readout for the signal peak as "a" mV.

(4) Next, set the attenuator to 6 dB attenuation (1/2 on the linear scale). Press PEAK SEARCH and record the marker readout for the signal peak as "b" mV.

(5) Determine the ratio of a half of "a" (mV) to "b" (mV) in percentage, and confirm that the ratio is within the specification (2b/a x 100 = between 97% to 103%).

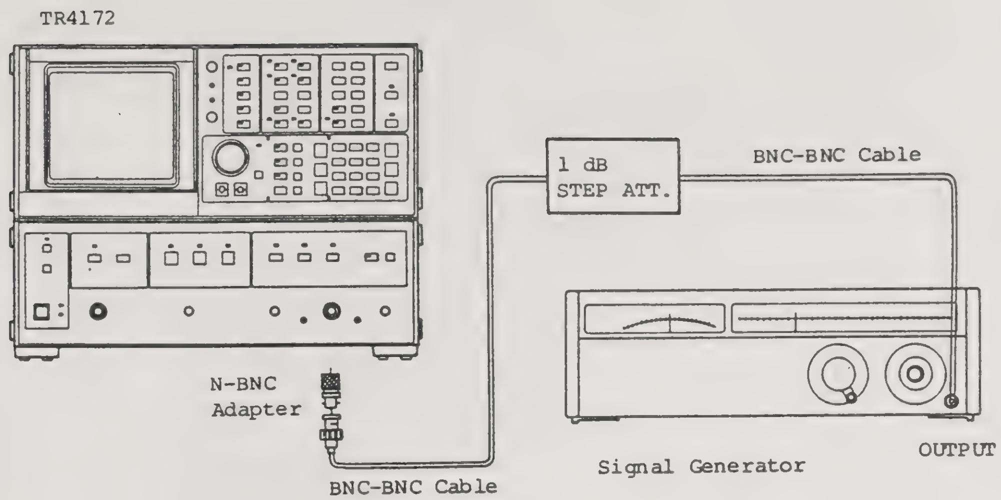


Fig. 12-29 Vertical scale linearity (lin.) test setup

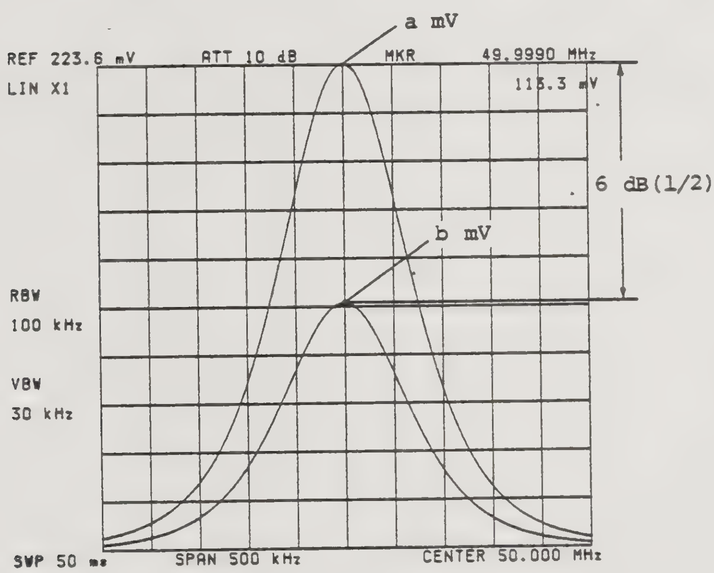


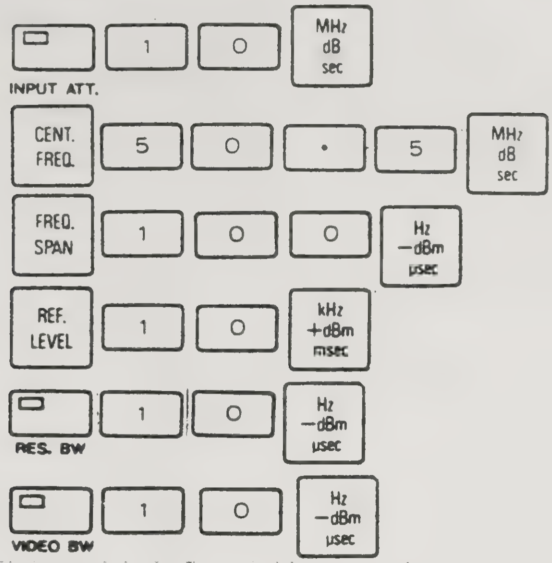
Fig. 12-30 Linear scale linearity check

12-4-6. Reference Level Accuracy

Specification: Within ±1.0 dB after calibration and error correction

Required instruments: Synthesized signal generator
External attenuator covering 0 to 110 dB at 10 dB steps

(1) While the instrument is in the initial default state, set it up as follows:



(2) Apply an SG output of 50.5 MHz, 0 dBm to the input of the analyzer via an external attenuator.

(3) Set the external attenuator to 0 dB attenuation. Press PEAK SEARCH to read the peak level of the signal response. Adjust the SG output level until the peak readout is 0.0 dBm.

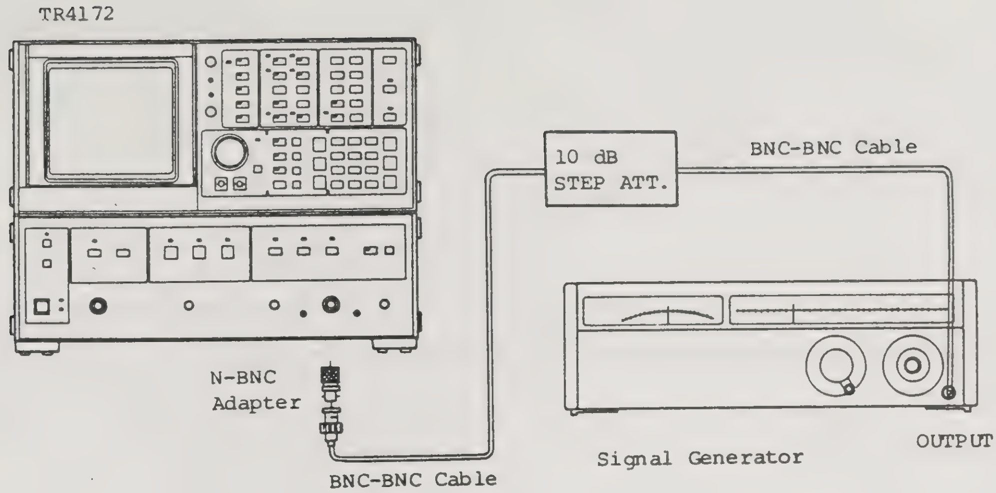


Fig. 12-31 Reference level accuracy test setup

(4) While increasing the attenuation of the external attenuator by 10 dB steps, lower the reference level by 10 dBm steps with $\boxed{\text{REF. LEVEL}}$ accordingly, and read each canceled level with $\boxed{}$ PEAK SEARCH. Confirm that marker readout error between each level is within ±1.0 dB. The following table shows the relationship between reference levels, external attenuator settings, and input levels.

Table 12-6 Ref. levels vs. external attenuator

REF level	Ext. ATT.	Input level
+10 dBm	0 dB	0 dBm
0 dBm	10 dB	-10 dBm
-10 dBm	20 dBm	-20 dBm
-20 dBm	30 dBm	-30 dBm
-30 dBm	40 dBm	-40 dBm
-40 dBm	50 dB	-50 dBm
-50 dBm	60 dB	-60 dBm
-60 dBm	70 dB	-70 dBm
-70 dBm	80 dB	-80 dBm
-80 dBm	90 dB	-90 dBm
-90 dBm	100 dB	-100 dBm

IF 10 dB STEP AMP.

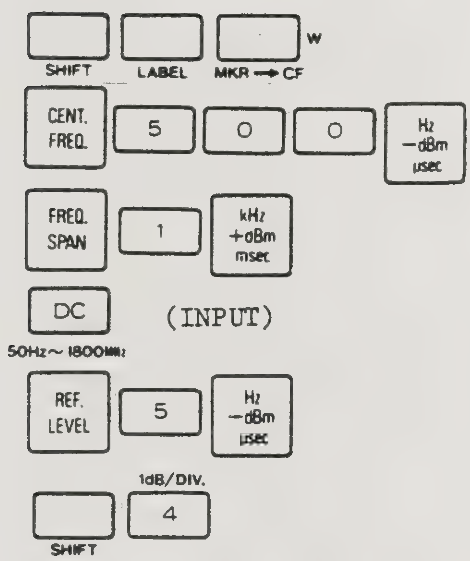
12-4-7. Frequency Response

Specification: 2 dB p-p over 50 Hz to 1 GHz
3 dB p-p over 50 Hz to 1.8 GHz
Within ±0.7 dB over 400 kHz to 1.8 GHz after error correction

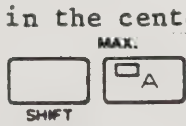
Required instrument: Signal generator

CAUTION: The frequency response of the signal generator itself causes a measurement error. Before using the generator, calibrate it by measuring the levels of major frequency points with a power meter.

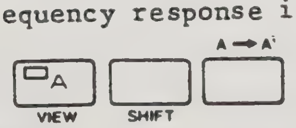
(1) While the instrument is in the initial default state, set it up as follows:



(2) Apply an SG output of 50 Hz, −10 dBm to the input of the analyzer. Adjust the REF. level until the signal response is positioned in the center of the vertical scale.

(3) Then press 

to enter the A Max Hold state. Slowly sweep the SG output frequency from 50 Hz through 1 kHz to store the frequency response in memory.

(4) Press 

to store the frequency response into A' memory.

(5) Update the setup for the instrument as follows:

[A] WRITE

[CENT. FREQ.] [1] [0] [kHz +dBm msec]

[FREQ. SPAN] [2] [0] [kHz +dBm msec]

(6) Press [ ] SHIFT [A] MAX. to enter the A Max Hold state. Slowly sweep the SG output frequency from 1 kHz through 20 kHz to store the frequency response in this range.

(7) Press [ ] SHIFT [A] BLANK VIEW to store the frequency response over 1 kHz to 20 kHz into memory A. The signal trace is blanked.

(8) Update the setup as follows:

[B] WRITE

[CENT. FREQ.] [2] [5] [0] [kHz +dBm msec]

[FREQ. SPAN] [5] [0] [0] [kHz +dBm msec]

(9) Press [ ] SHIFT [B] MAX. to select the B Max Hold state. Slowly sweep the SG output frequency from 20 kHz through 500 kHz to store the frequency response.

(10) The press [ ] B → B' to store the frequency response over 20 to 500 kHz into memory B'.

(11) Now update the setup as follows:

[B] WRITE

[CENT. FREQ.] [5] [MHz dB sec]

[FREQ. SPAN] [1] [0] [MHz dB sec]

(12) Press [ ] SHIFT [B] MAX. to select the B Max Hold state. Slowly sweep the SG output frequency from 500 kHz through 10 MHz to store the frequency response between these frequencies.

(13) Press [B] (VIEW) to store the frequency response over 500 kHz to 10 MHz into memory B.

(14) Operation of [A] (VIEW), [ ] (A' VIEW), and [ ] (B' VIEW) will show the frequency response over 50 Hz through 10 MHz on the display. Record the maximum and minimum levels in the frequency response.

(15) Update the setup as follows:

[A] (WRITE)

[SHIFT] [B] (BLANK)

[SHIFT] [ ] (A' BLANK)

[SHIFT] [ ] (B' BLANK)

[CENT. FREQ.] [9] [0] [0] [MHz dB sec]

[FREQ. SPAN] [1] [8] [0] [0] [MHz dB sec]

(16) Press [SHIFT] [A] (MAX.) to select the A Max Hold state. Slowly sweep the SG output frequency from 10 MHz through 1800 MHz to store the frequency response.

(17) Superimpose the previous recorded frequency response between 50 Hz and 10 MHz over the last one (between 10 and 1800 MHz), to make sure that the peak and dip of the frequency response is less than 2 dB p-p over 50 Hz to 1000 MHz. Also confirm that the frequency response error is less than 3 dB p-p over 50 Hz to 1800 MHz.

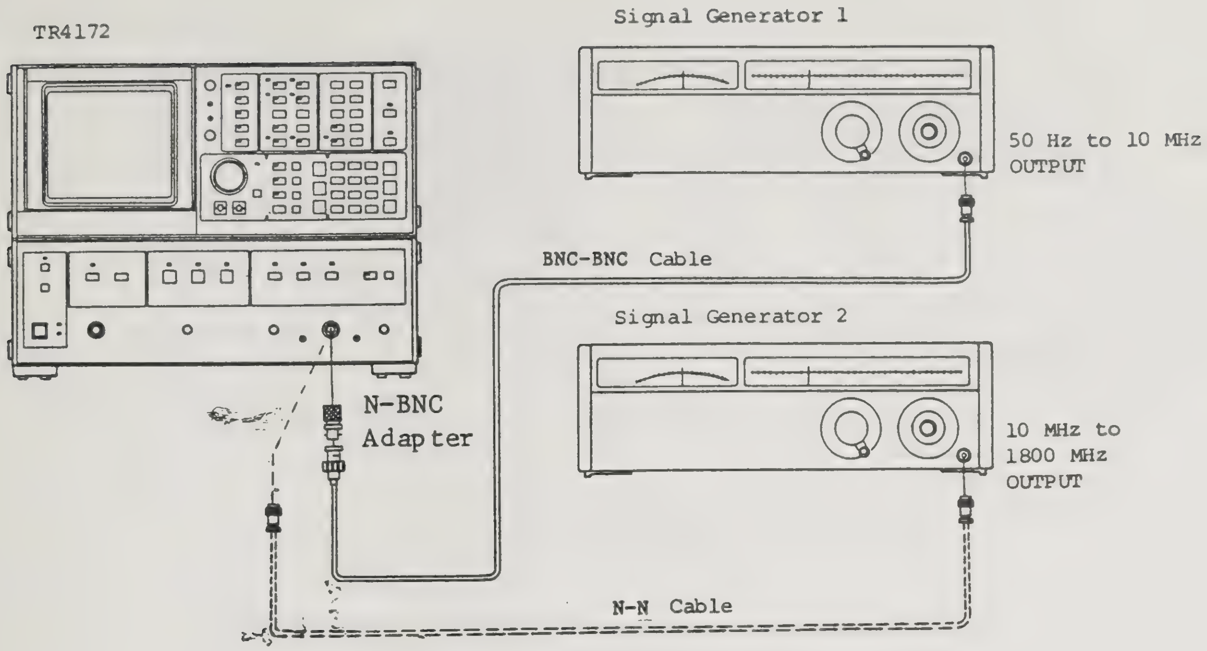


Fig. 12-32 Frequency response test setup

12-4-8. Spurious Response (Secondary Harmonic Distortion)

Specification: -60 dB or less when the center frequency ≧ 20 MHz with an input level of -10 dBm.
-45 dB or less when the center frequency < 20 MHz with an input level of -10 dBm.

Required instrument: Low distortion oscillator (with the 2nd harmonic level of less than -70 dB)

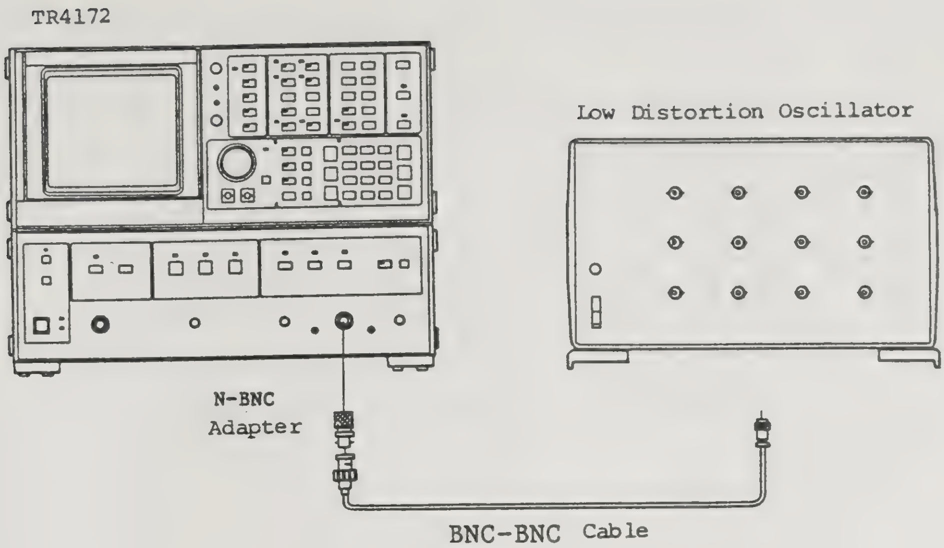


Fig. 12-33 2nd harmonic distortion check setup

(1) While the instrument is in the initial default state, set it up as follows:

[INPUT ATT.] [. 0] [MHz dB sec]

[CENT. FREQ.] (Frequency of the Low distortion oscillator)

[FREQ. SPAN] [2] [0] [MHz dB sec]

[VIDEO BW] [3] [kHz +dBm msec]

[REF. LEVEL] [1] [0] [Hz −dBm µsec]

(2) Apply a -10 dBm signal from the low-distortion oscillator to the input of the analyzer.

(3) Press [PEAK SEARCH] [MKR → CF] [MKR/Δ → STEP SIZE] [MKR → REF.] to read the marker readout for the input signal level.

(4) Next, press [CENT. FREQ.] [⇧] to double the center frequency. Read the 2nd harmonic distortion level at that frequency to confirm that it is less than -60 dB below the fundamental component level (less than -45 dB when the input frequency is less than 20 MHz).

(5) Check the distortion at other frequencies in the same way.

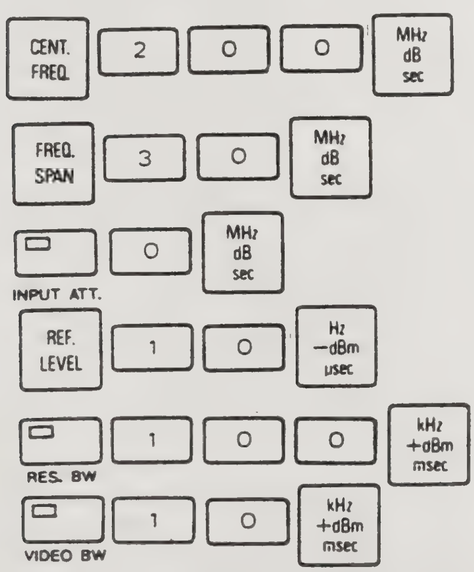
Note: An ordinary signal generator with a low-pass filter provided at its output to eliminate the 2nd harmonic distortion may be used instead of the low-distortion oscillator (with a 2nd harmonic distortion level of less than -70 dB). If the former type of signal generator is used, set the level at the input terminal to -10 dBm after the signal passes through the low-pass filter and input cable.

12-4-9. Spurious Response (Two signal distortion)

Specification: Less than -50 dB for two signals of -10 dBm with separation greater than 5 MHz
Less than -45 dB for two signals of -10 dBm with separation less than 5 MHz

Required instruments: Two signal generators
Isolated power splitter

(1) While the instrument is in the initial default state, set it up as follows:



(2) Next, set the output of one of the signal generators to 197 MHz, -4 dBm (when a 6 dB power splitter is used), and set the output of the other signal generator to 203 MHz, -4 dBm (with a 6 dB power splitter). Apply these SG outputs to the power splitter, and couple the output of the power splitter to the input of the analyzer.

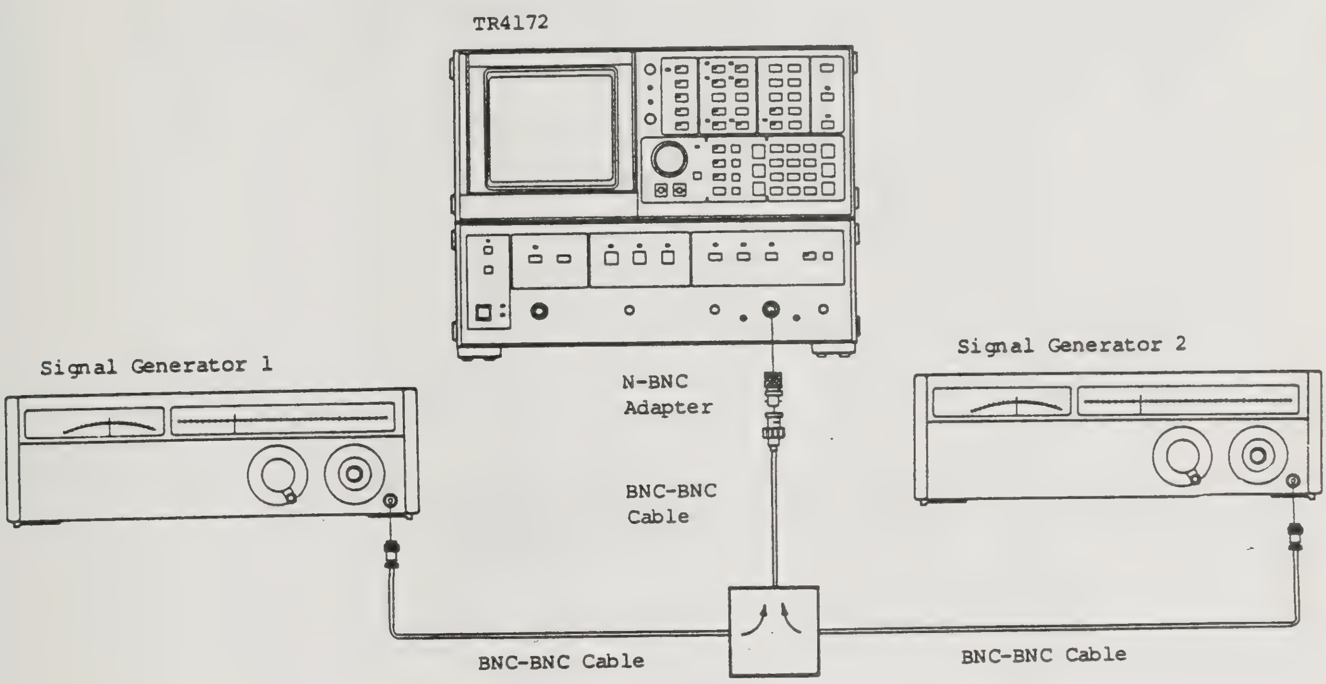


Fig. 12-34 Spurious response (Two signal distortion) test setup

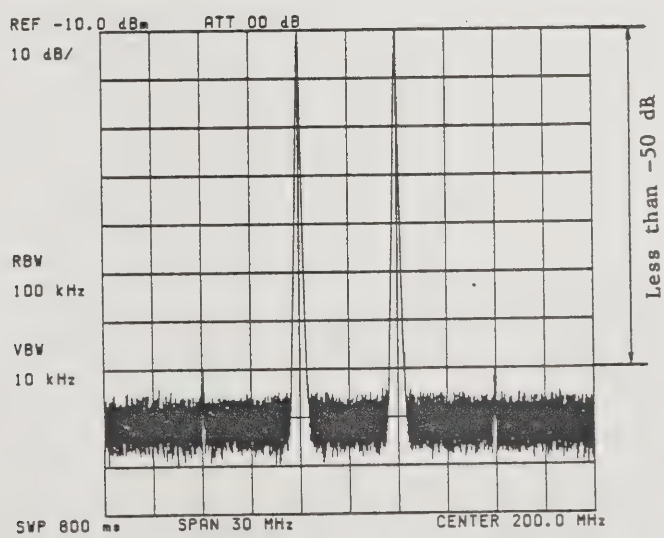


Fig. 12-35 Two signals separated

Note: With the above test setup, two signals of -10 dBm, and 6 MHz apart from each other are applied to the analyzer. To prevent interference between the two signal-generator outputs, the power splitter used must be a high isolation type.

(3) Read the two signal distortion level from the display, to make sure that it is within the specification. (Fig. 12-35)

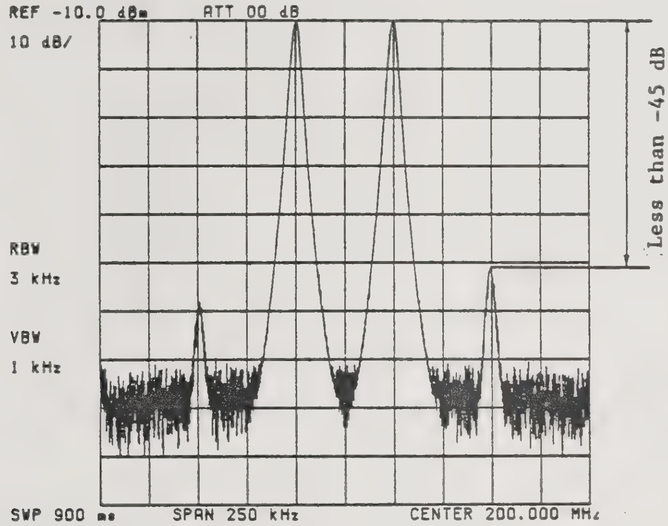
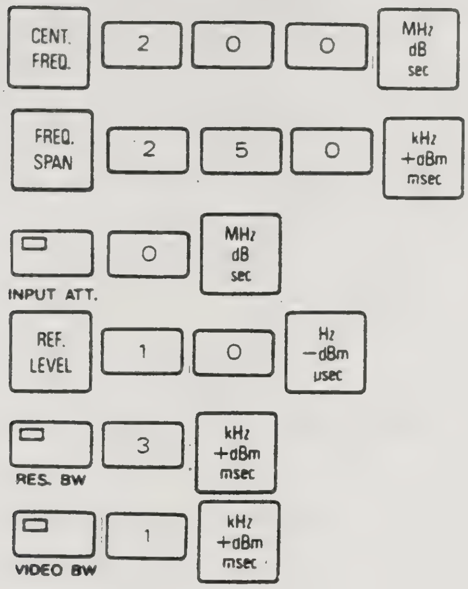


Fig. 12-36 Spurious response two signal distortion test

(4) Update the panel setup on the instrument as follows, and check to make sure that the two-signal distortion level is within the specification when the difference in the two signal frequencies is 50 kHz: (Fig. 12-36)



Output frequency of SG1: 199.975 MHz

Output frequency of SG2: 200.025 MHz

12-4-10. Gain Compression

Specification: Less than 1 dB at an input level of 0 dBm with the input attenuator set at 0 dB.

Required instrument:
- Signal generator
- External attenuator covering 0 to 110 dB at 10 dB steps.

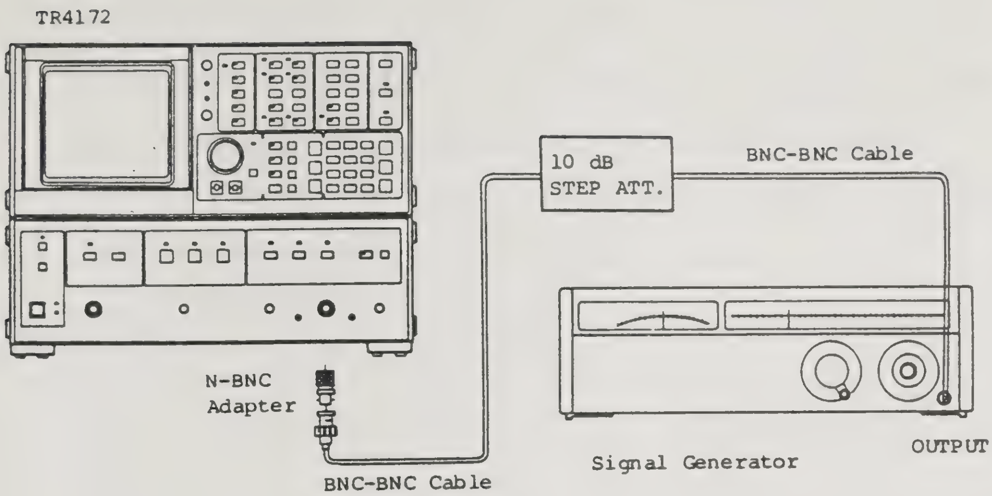
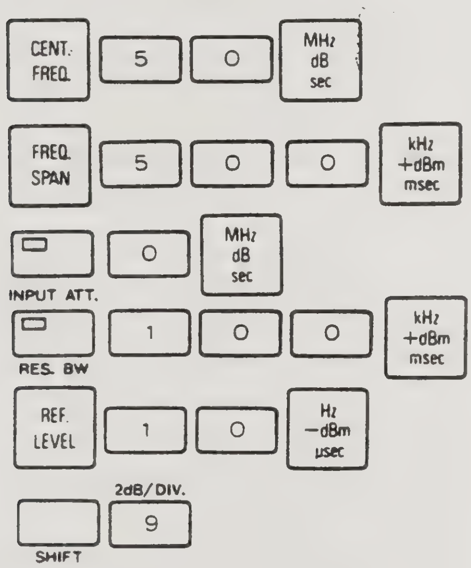


Fig. 12-37 Gain compression test setup

(1) While the instrument is in the initial default state, set it up as follows:



(2) Apply an SG output of 50 MHz, 0 dBm to the input of the analyzer via the external attenuator. Set the external attenuator to 10 dB of attenuation. Press [ ] PEAK SEARCH to read the marker readout for the input signal level (-10 dB).

(3) Set the external attenuator to 0 dB of attenuation and apply an input signal level of 0 dBm to the analyzer. Press [REF. LEVEL] [0] [MHz dB sec] and [ ] PEAK SEARCH to read the signal level.

(4) Add 10 dB to the marker readout of the above (2) to assume a level without a gain compression. Compare this level with the level readout obtained when an input signal of 0 dBm is applied to the analyzer's input, to check that the gain compression is less than 1 dB.

12-4-11. Input Attenuator Switching Accuracy

Specification: Less than ±0.5 dB at 50 MHz over 0 to 50 dB

Required instruments: • Signal generator

• External attenuator of 10 dB stepping

(1) While the instrument is in the initial default state, set it up as follows:

[CENT. FREQ] [5] [0] [MHz dB sec]

[FREQ. SPAN] [1] [0] [0] [kHz +dBm msec]

[ ] RES. BW [1] [0] [0] [kHz +dBm msec]

[ ] VIDEO BW [1] [0] [0] [kHz +dBm msec]

[ ] INPUT ATT. [0] [MHz dB sec]

[REF. LEVEL] [5] [0] [·] [5] [Hz −dBm μsec]

[ ] SHIFT [5] 0.1dB/DIV.

(2) Apply an SG output of 50 MHz in frequency and 0 dB in level to the analyzer input via an external attenuator with an attenuation of 50 dB.

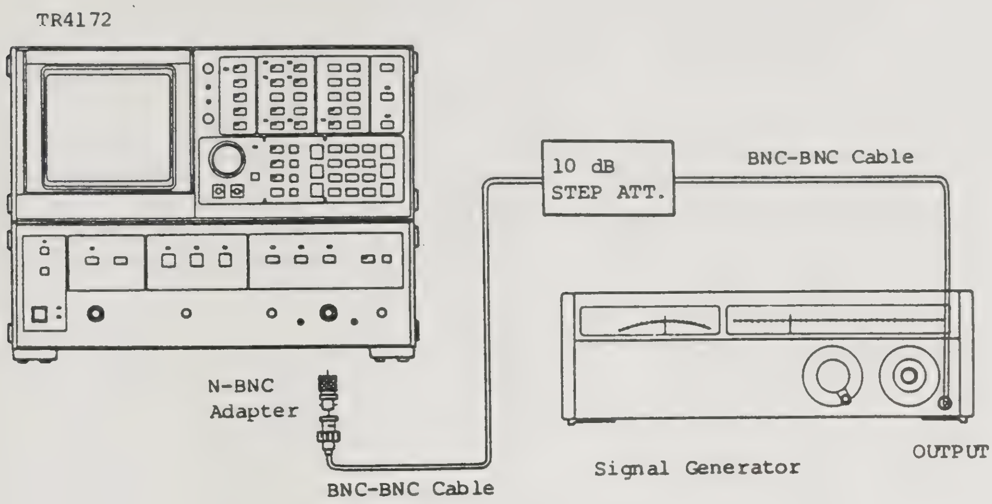


Fig. 12-38 Input attenuator switching accuracy setup

(3) Adjust the SG output level until the input signal response is positioned in the center of the vertical graticule.

(4) Press [INPUT ATT.] [1] [0] [MHz/dB/sec] to set the external attenuator to 40 dB of attenuation. Verify that the signal level is within ±5 division (0.5 dB) from the center of the vertical scale.

Fig. 12-39 Input attenuator switching accuracy test

(5) Subsequently change both input attenuator and external attenuator settings each by 10 dB sequentially as shown in the following table. Verify that the attenuator accuracy is within ±5 divisions (0.5 dB) with respect to 0 dB over each settings.

Table 12-7

INPUT ATT.	0 dB	10 dB	20 dB	30 dB	40 dB	50 dB
EXT. ATT.	50 dB	40 dB	30 dB	20 dB	10 dB	0 dB

12-4-12. Calibration Output Level Accuracy

Specification: -20 dBm ±0.3 dB over 20°C to 30°C

Required instrument: Power meter

(1) Connect a power meter to the CAL. OUT. connector on the front panel of the instrument for direct CAL. OUT. level checking.

(2) The power meter used should be calibrated at 50 MHz. Verify that the CAL. OUT. level is within -20 dBm ±0.3 dB.

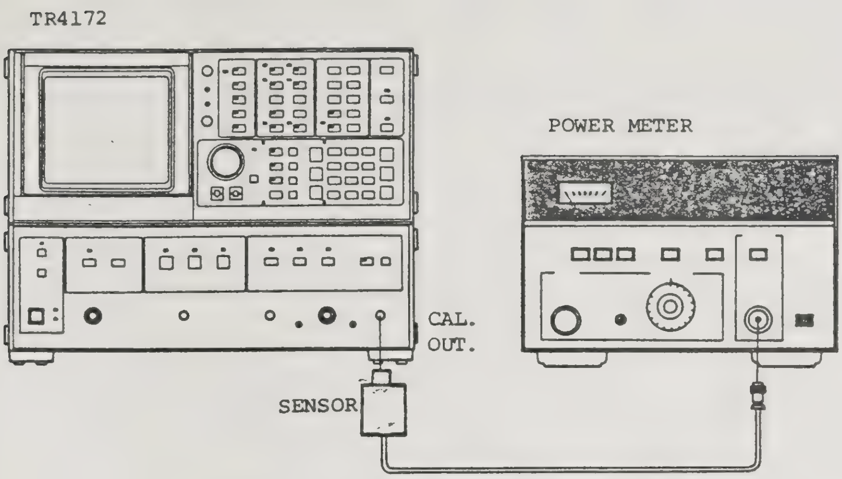


Fig. 12-40 CAL. OUT. level measurement setup

12-5. TRACKING GENERATOR PERFORMANCE CHECK

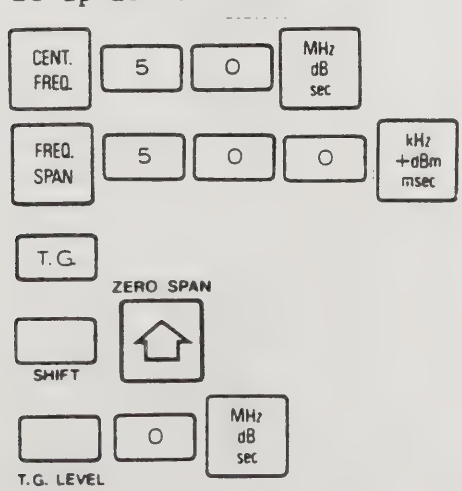
This paragraph describes the performance check procedures for the built-in tracking generator.

12-5-1. T.G. Output Level Accuracy

Specification: Within 0 dBm ±1.0 dB at an output frequency of 50 MHz, with the T.G. attenuator set at 0 dB.

Required instrument: Power meter

(1) While the instrument is in the initial default condition, set it up as follows:



(2) Measure the T.G. output level with a power meter calibrated at 50 MHz.

(3) Verify that the measured level is within the specification of 0 dBm ±1.0 dB.

(4) Now proceed with T.G. output frequency response check.

12-5-2. T.G. Output Frequency Response

Specification: Within ±0.7 dB over 400 kHz to 1500 MHz
Within ±1 dB over 400 kHz to 1800 MHz
Both with respect to a 50 MHz level, with the T.G. attenuator set at 10 dB attenuation.

Required instrument: Power meter

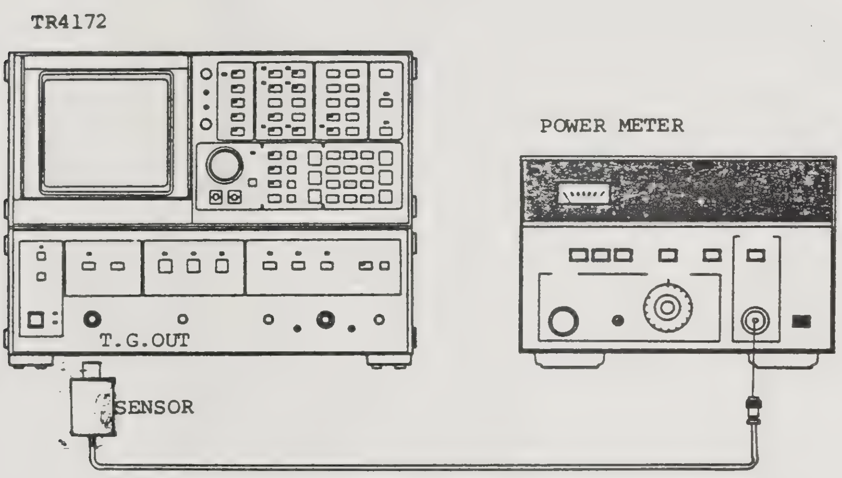
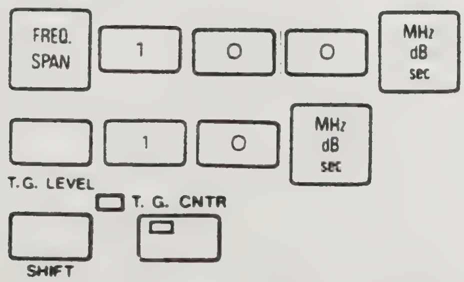


Fig. 12-41 T.G. output level measurement setup

(1) After checking the T.G. output level, set up the instrument as follows:



(2) Use the output level at 50 MHz as a reference.

(3) Next, press [CENT. FREQ.] [4] [0] [0] [kHz +dBm msec] . Use the DATA knob to sweep the center frequency from 400 kHz through 1800 MHz, and verify that the frequency response is within ±0.7 dB over 400 kHz to 1500 MHz, and within ±1 dB over 400 kHz to 1800 MHz.

12-5-3. T.G. Output Level Switching Accuracy (T.G. ATT. Switching Accuracy)

Specification: Within ±0.5 dB at 50 MHz over 0 to 50 dB

Required instrument: Attenuator covering 0 to 110 dB attenuation at 10 dB steps

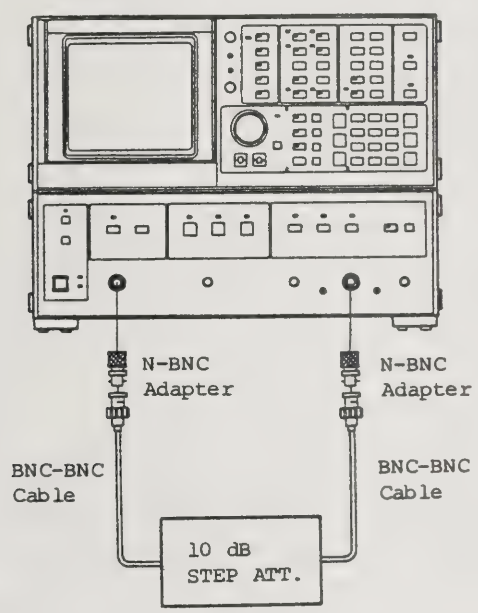
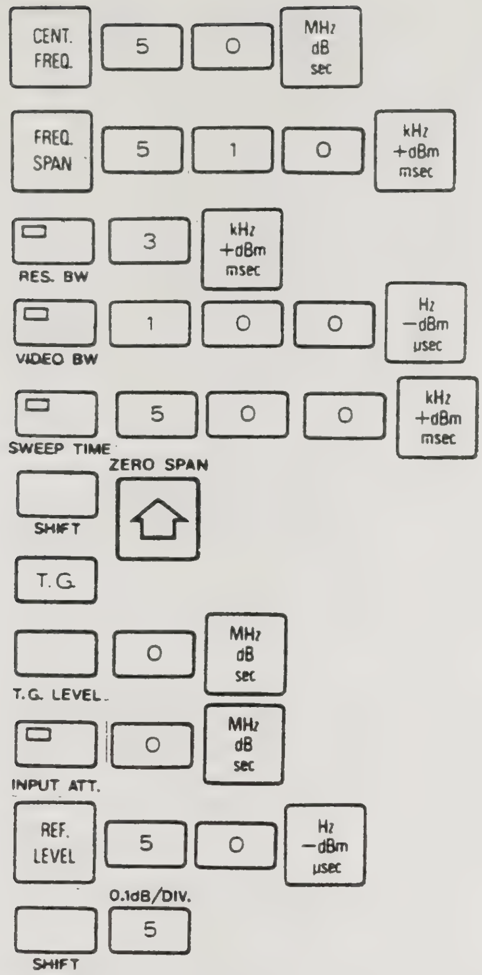


Fig. 12-42 T.G. attenuator accuracy check setup

(1) While the instrument is in the initial default condition, set it up as follows:
Connect the T.G. output to the INPUT-1 connector via an external attenuator 50 dB of attenuation, then enter as follows:



(2) Next, [REF. LEVEL]. Adjust the DATA knob until the T.G. output signal response is positioned in the center of the vertical scale. Use this signal level as a reference for the following measurements.

(3) Press [T.G. LEVEL] [1] [0] [MHz dB sec] to set the T.G. attenuator to 10 dB. Set the external attenuator to 40 dB. Verify that the then signal level is within ±5 divisions (0.5 dB) with respect to the reference level obtained just above.

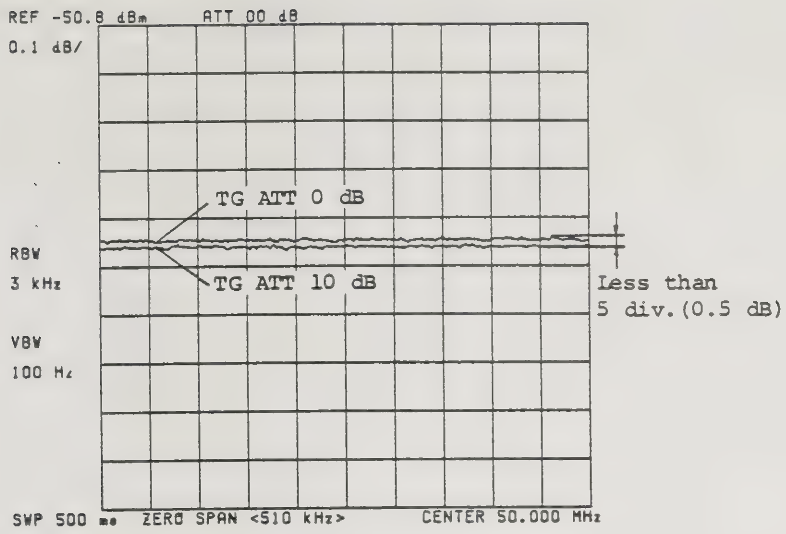


Fig. 12-43 T.G. attenuator accuracy

(4) Subsequently change the T.G. and external attenuator settings each by 10 dB as shown in the following table, and make sure that each signal level is within ±5 divisions (0.5 dB) with respect to the reference level, over the T.G. attenuator settings of 0 to 50 dB.

Table 12-8

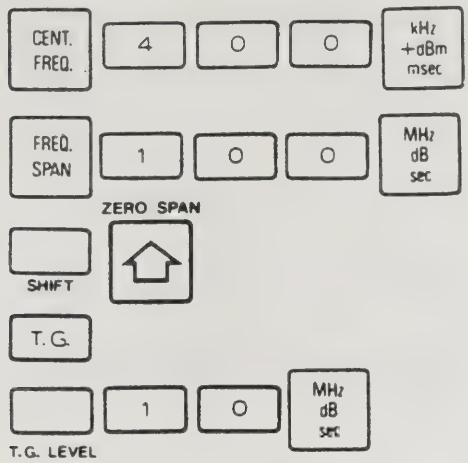
TG. ATT.	0 dB	10 dB	20 dB	30 dB	40 dB	50 dB
EXT. ATT.	50 dB	40 dB	30 dB	20 dB	10 dB	0 dB

12-5-4. Tracking Generator Output Spurious

Specification: Higher harmonics: Less than −20 dB
Spurious other higher harmonics:
Less than −30 dB over 400 kHz to 1500 MHz
Less than −25 dB over 1500 MHz to 1800 MHz
Nonharmonic spurious which crosses the fundamental signal component: Less than −30 dB over 400 kHz to 1800 MHz

Required instrument: Spectrum analyzer having a frequency response up to 4 GHz

(1) While the instrument is in the initial default condition, set it up as follows:



(2) Apply the T.G. output to the input of a spectrum analyzer having direct observation capability up to 4 GHz.

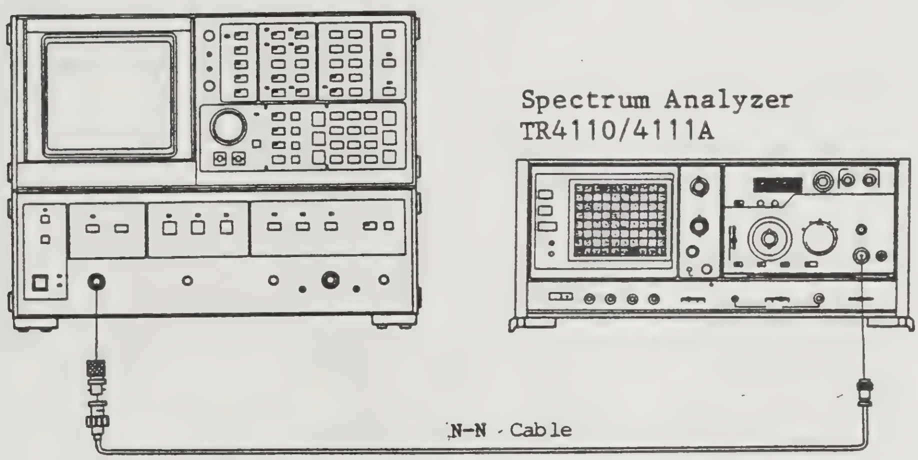


Fig. 12-44 T.G. output spurious test setup

(3) Press 

. While turning the DATA knob to sweep the center frequency from 400 kHz through 1800 MHz, verify that harmonic and nonharmonic spurious levels are within the specifications.

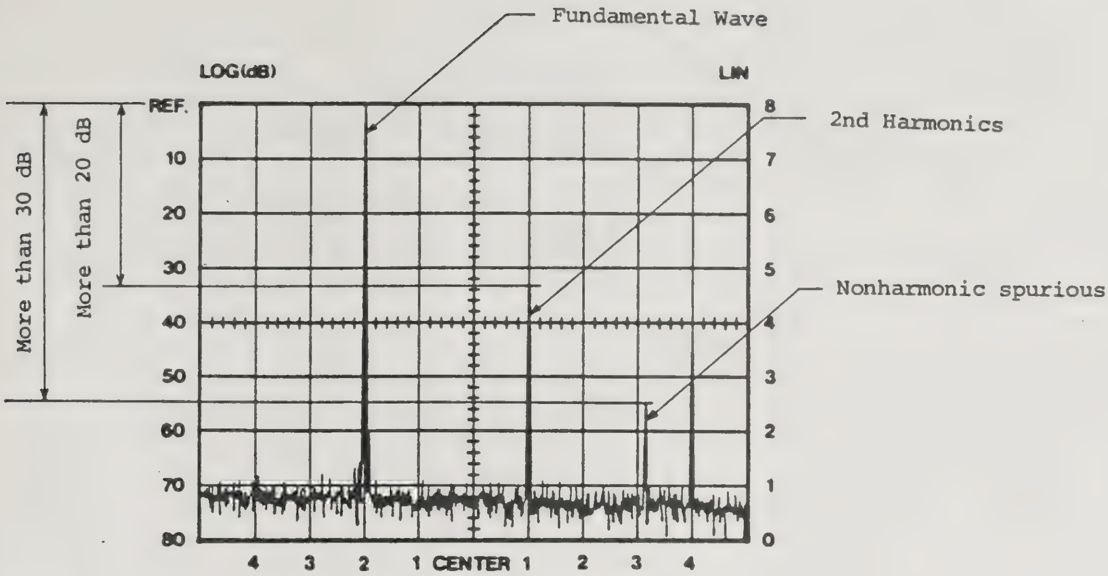


Fig. 12-45 T.G. output spurious test

12-5-5. Tracking generator Frequency Tracking

Specification: Drift: 30 Hz/min
300 Hz/10 min
The peak must be obtained at a resolution bandwidth of 10 Hz.

(1) While the instrument is in the initial default condition, set it up as follows:
Connect the T.G. output to the INPUT-1 of the TR4172 Analyzer.

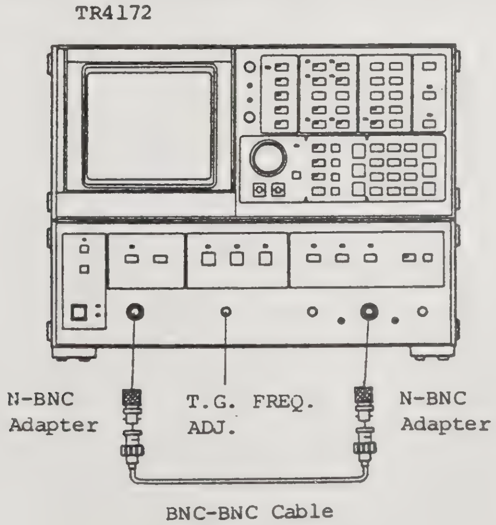
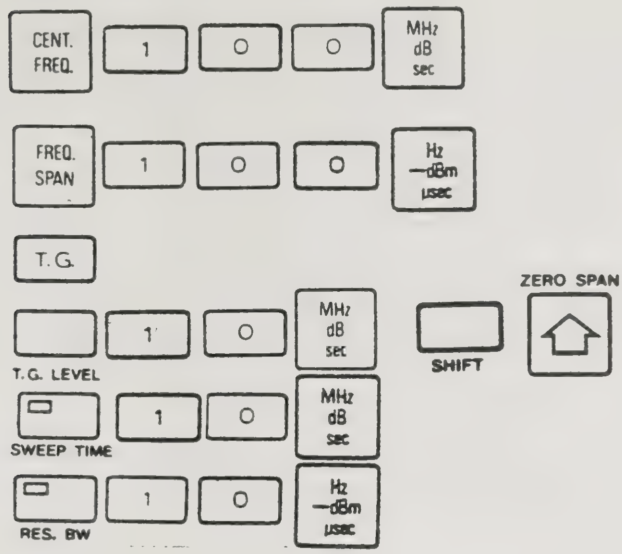


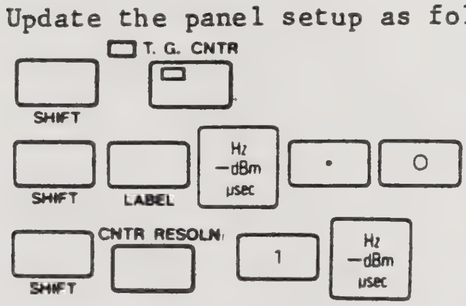
Fig. 12-46 T.G. tracking setup

Now enter as follows:



(2) Adjust the front control named T.G. FREQ. ADJ. to make sure that the peak of the T.G. output level can be obtained on the display.

(3) Update the panel setup as follows:



(T.G. count mode)

(4) Count the T.G. output frequency and verify that the frequency drifts, 1 and 10 minutes later are both within the specification.

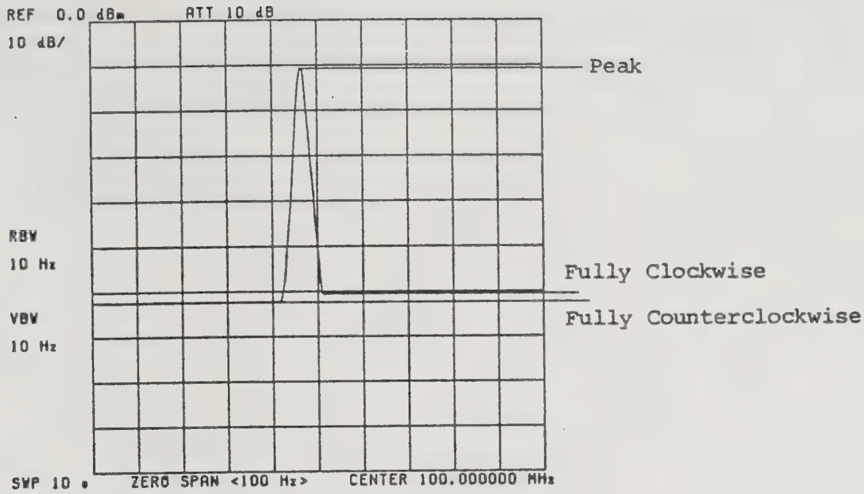
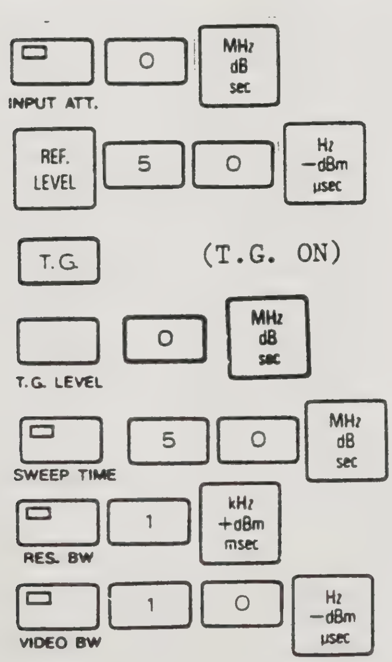


Fig. 12-47 T.G. frequency tracking

12-5-6. T.G. Leakage Level

Specification: Less than -100 dBm over 0 to 1500 MHz
Less than -95 dBm over 0 to 1800 MHz

(1) While the instrument is in the initial default state, set it up as follows. Leave both the T.G. OUTPUT and INPUT-1 connectors open (unplug the adapter if plugged).



(2) With no signal applied to the input of the analyzer, observe the response on the display over 0 to 1800 MHz to verify that no response exceeding the specification is observed. Ignore the "UNCAL" message, if appears.

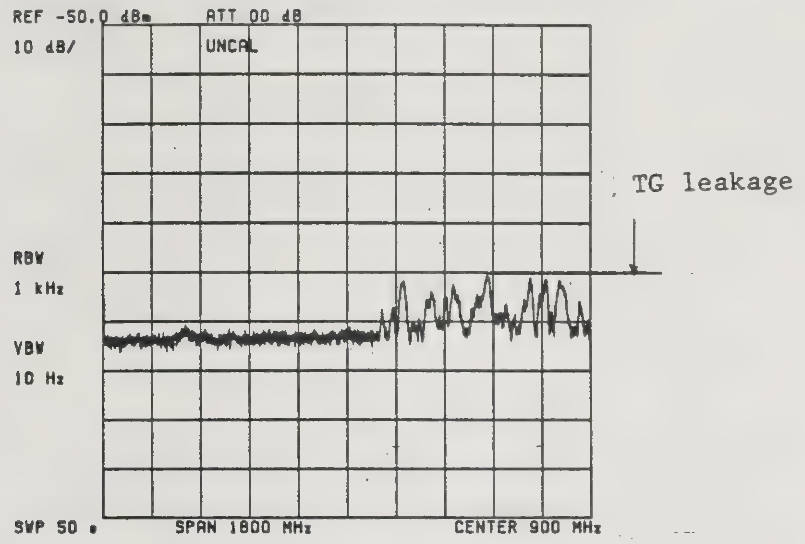


Fig. 12-48 T.G. output leakage

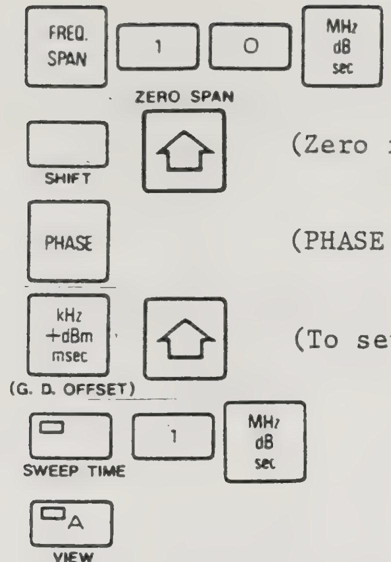
12-6. PHASE AND GROUP DELAY DISPLAY PERFORMANCE CHECK

This paragraph describes check procedures for the phase and group delay (G.D.) display features contained in the instrument.

12-6-1. Phase Display Range Accuracy

Specification: Within ±3% at each display range ±180 ±5 deg.

(1) While the instrument is in the initial default state, set it up as follows:
Connect the TRACKING GENERATOR OUTPUT connector to the INPUT-1 connector, then enter as follows:



(Zero frequency span)

(PHASE mode)

(To set G.D. Offset to "400")

(2) Operate PEAK SEARCH and then SHIFT NEG. PEAK S. to read the peak and bottom values on the display. Verify that these values are within the specification of 180 ±5 deg. and -180 ±5 deg. respectively.

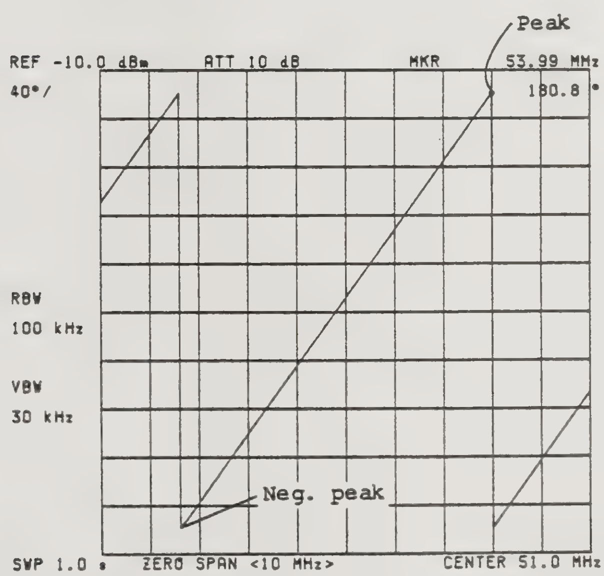
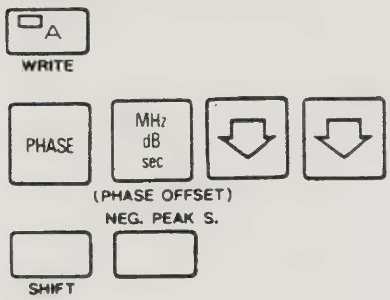


Fig. 12-49 Phase display range

12-6-2. Phase Offset

Specification: Must be variable over ± 250 deg.

(1) After verifying the phase display range, proceed with the following panel setup:



(Set phase offset to 0)

(2) While slowly turning the DATA knob to increase phase offset from 0 to 4096, verify that the marker on the display moves over more than 500 deg. as shown below:

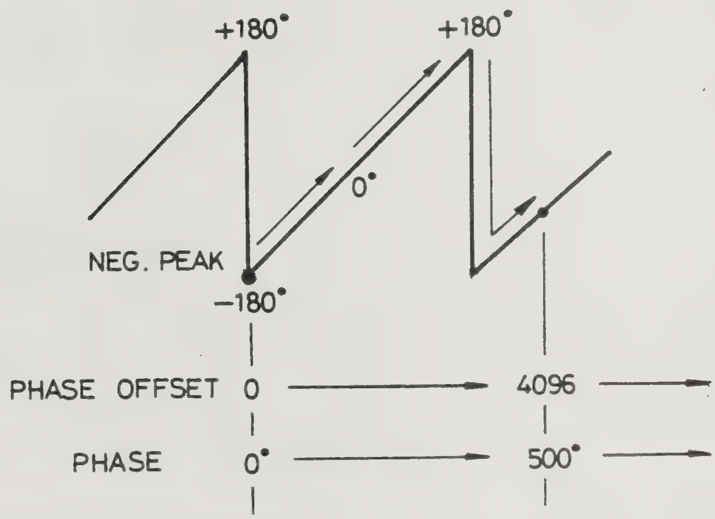
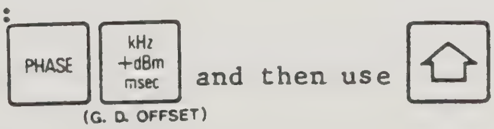


Fig. 12-50 Phase offset test

12-6-3. Group Delay Offset

Specification: Must be variable over more than 3600 deg.

(1) After verifying the phase offset, proceed with the following setup:

Press  and then use to set group delay offset to 2000.

(2) Press [kHz +dBm msec] (G. D. OFFSET) again and then use [⇩] to set group delay offset fine to 0.

(3) Now press [MHz dB sec] (PHASE OFFSET). Adjust phase offset with the DATA knob so that the switching point from +180 deg. is aligned to the leftmost graticule as shown below:

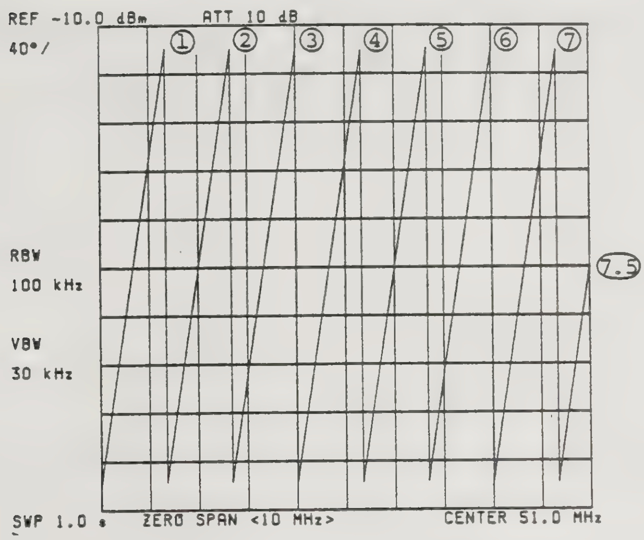


Fig. 12-51 Group Delay Offset test

(4) Check to make sure that there are 7.5 saw-tooth waves (360° x 7.5 = 2700 deg.) between the leftmost and rightmost graticules. G.D. offset covers from 0 to 4096, which allows for phase variation of more than 5400 deg., since G.D. of 2000 corresponds to 2700 deg.

12-6-4. Group Delay Offset Fine

Specification: 50.6 deg. ±2.5 deg.

(1) After verifying G.D. offset, proceed with the following setup: Press [PHASE] [kHz +dBm msec] (G. D. OFFSET) and then use [⇩] to set G.D. offset to 0.

(2) Press [MHz dB sec] (PHASE OFFSET). Adjust phase offset with the DATA knob until the phase response is positioned to the center of the screen.

(3) Press [PHASE]. Set phase to 8 deg./div. with the DATA knob.

(4) Press [PHASE] [kHz +dBm msec] (G. D. OFFSET) and then again [kHz +dBm msec] (G. D. OFFSET). Adjust the DATA knob to set G.D. offset fine to 250.

(5) Then press [PEAK SEARCH] [▲] [SHIFT] [NEG. PEAK S.]. Verify with the delta marker that the deviation read is within 50.6 $\pm$2.5 deg.

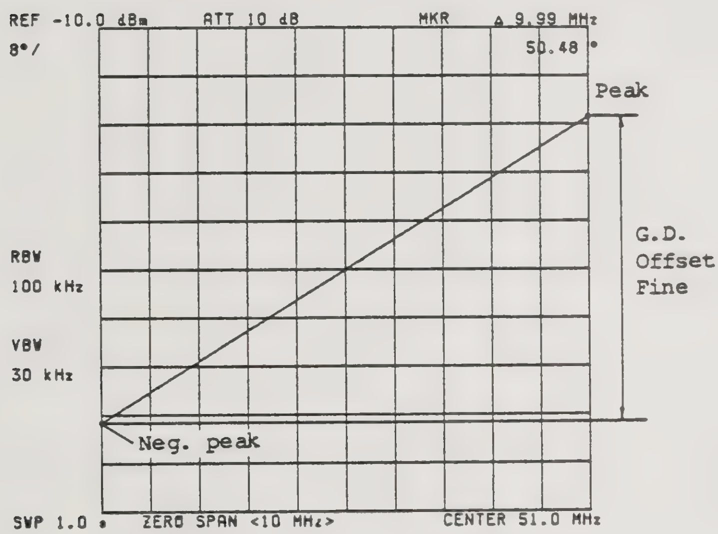


Fig. 12-52 G.D. offset fine

12-6-5. Group Delay Display Range Accuracy

Specification: Within $\pm$3% at frequency span of 10 MHz, 40 deg./div. (20°C to 30°C)

(1) After verifying G.D. offset fine, proceed with this check.

First press [PHASE], then adjust the DATA knob to set the phase to 40 deg./div.

(2) Press [kHz +dBm msec] (G. D. OFFSET) and then use [⇧] to set G.D. offset to "400".

(3) Press [GROUP DELAY] to obtain group delay display, then press [▭A] (VIEW) to store the waveform.

(4) Use the delta marker to read the delay time shown in the following figure, and verify that the readout value is within ±3% (96 ns) of the display range.

(5) Press WRITE

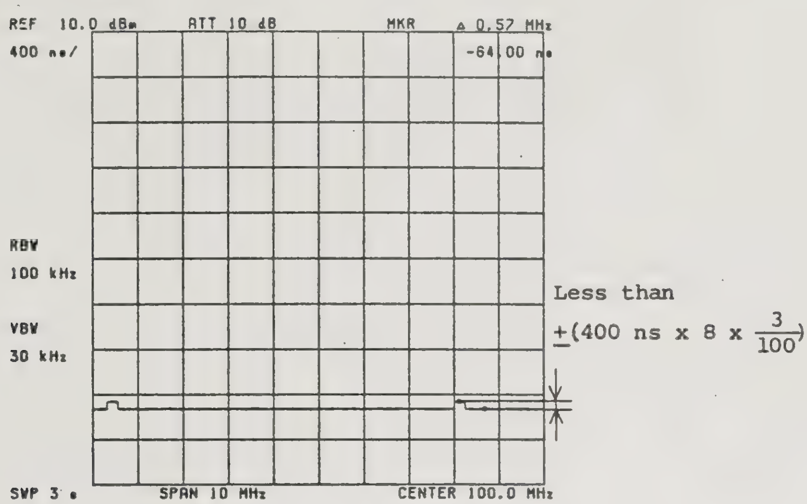


Fig. 12-53 Group Delay display range accuracy

12-6-6. Phase Stability

Specification: Less than 0.1 deg. p-p/100 ms at frequency span of 10 MHz, resolution bandwidth of 100 kHz, and video bandwidth of 30 kHz

(1) After verifying G.D. display range accuracy, proceed with this check. First press PHASE kHz +dBm msec (G. D. OFFSET), then use ⇩ to set G.D. offset to 0.

(2) Press kHz +dBm msec (G. D. OFFSET) again. Use ⇩ to set G.D. offset fine to 0.

(3) Press MHz dB sec (PHASE OFFSET), then adjust the DATA knob until the signal response is positioned to the center of the vertical scale.

(4) Press PHASE, then use the DATA knob to set the phase to 4 deg./div.

(5) Press MHz dB sec (PHASE OFFSET) again, then adjust the DATA knob until the signal response is positioned to the center of the vertical scale.

(6) Press PHASE, then use the DATA knob to set the phase to 0.2 deg./div.

(7) Verify that the ripple within one division of the horizontal scale is less than 0.5 div. (0.1 deg.) as shown below.

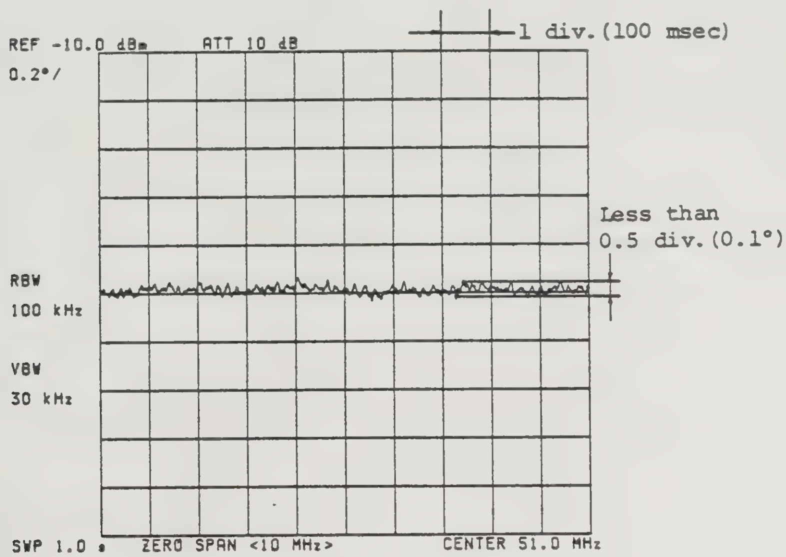


Fig. 12-54 Phase stability check

12-7. SUPPLY VOLTAGE VARIATION CHECK

Specification: ±10% (+4%, -10% for 240 Vac)

Required instruments: Slidac transformer
AC voltmeter (for voltage monitoring)

(1) While monitoring the AC output voltage of the slidac transformer with an AC voltmeter, set it to the specified supply voltage.

(2) Plug the analyzer to the AC outlet on the slidac transformer.

(3) Power the instrument. While it is in the initial default condition, apply the CAL. OUT. signal to the input.

(4) While varying the slidac transformer output voltage from -10% to +10% (+4% for 240 V) of the specified supply voltage, verify that nothing changes in the display information.

		Test item		Specifications	Date
Perform-ance test re-quiring no meas-uring instru-ments	1	Impact test		Lift the front bottom of the instrument to a height of 3 cm from the test deck surface, then drop it on the deck, and and verify that the instrument operates normally. Carry out similar drop test for the rear and both sides of the instrument.	
	2	Display area size		100 x 120 mm or more	
	3	Pattern and orthogonal distortion		Within ±1 mm	
	4	Trace align		Variable over more than ±3 deg.	
	5	Intensity and focus			
	6	Frequency span accuracy	When freq. span >500kHz	Within ±3%	
			When freq. span ≦500kHz	Within ±5%	
	7	Marker display accuracy	NORMAL	Within center frequency accuracy ±accuracy of the span between marker and center frequency	
			T.G. Counter	Same as center frequency accuracy.	
			Count	Master oscillator accuracy x display frequency ±2 counts or less	

		Test item			Specifications	Date
Performance test requiring no measuring instruments	8	Resolution bandwidth accuracy	3 dB bandwidth	1 MHz	Within 1 MHz ±200 kHz	
				300 kHz	Within 300 kHz ±60 kHz	
				100 kHz	Within 100 kHz ±20 kHz	
				30 kHz	Within 30 kHz ±6 kHz	
				10 kHz	Within 10 kHz ±2 kHz	
				3 kHz	Within 3 kHz ±600 Hz	
				1 kHz	Within 1 kHz ±200 Hz	
				300 Hz	Within 300 Hz ±60 Hz	
				100 Hz	Within 100 Hz ±20 Hz	
				30 Hz	Within 30 Hz ±6 Hz	
				10 Hz	Within 10 Hz ± 2 Hz	
			Q.P. option 6 dB bandwidth	120 kHz	Within 120 kHz ±20 kHz	
				9 kHz	Within 9 kHz ±1 kHz	
				200 Hz	Within 200 Hz ±20 Hz	
	9	Resolution bandwidth selectivity	60 dB bandwidth	1 MHz	<10 MHz	
				300 kHz	< 3 MHz	
				100 kHz	< 1.3 MHz	
				30 kHz	< 390 kHz	
				10 kHz	< 130 kHz	
				3 kHz	< 39 kHz	
				1 kHz	< 13 kHz	
				300 Hz	< 3.9 kHz	
				100 Hz	< 1.3 kHz	
				30 Hz	< 390 Hz	
				10 Hz	< 130 Hz	

		Test item		Specifications	Date
Performance test requiring no measuring instruments	10	Resolution bandwidth switching level accuracy	With reference to 300 kHz resolution bandwidth before error correction.	Within ±1.0 dB	
	11	Residual FM	When freq. span ≧ 510 kHz	Within 8 kHz p-p/sec.	
			When freq. span < 50 kHz	Within 2Hz p-p/sec.	
	12	Frequency stability	When freq. span < 50 kHz	Within 30Hz p-p/min.	
	13	Noise sideband	30 kHz from carrier with 1 kHz resolution bandwidth	Less than -80 dB	
			20 kHz from carrier with 1 kHz resolution bandwidth	Less than -75 dB	
	14	Adjacent spurious	From carrier	Less than 70 dB	
	15	Residual response	No input signal with input ATT. set at 0 dB	Less than 100 dBm	
	16	Noise level — Center freq. > 1 MHz with video BW of 1 Hz	Resolution bandwidth 1 MHz	Less than -80 dBm	
			Resolution bandwidth 300 kHz	Less than -85 dBm	
			Resolution bandwidth 10 kHz	Less than -100 dBm	
			Resolution bandwidth 3 kHz	Less than -105 dBm	
			Resolution bandwidth 10 Hz	Less than -130 dBm	
	17	Fine tune level deviation		Within 0.5 dBp-p	
	18	Counter operation	Operating frequency	400 kHz to 1500 MHz	
			TG 3RD LO 23 M VCO 3RD LO 2 M VCO TG 200 M IF 1ST LO IF 2ND LO 204M 3RD LO 153 M 4TH LO 33 M 1ST LO AUTO	Should normally count each local frequency.	

		Test item				Specifications	Date
Performance test requiring no measuring instruments	19	Analog sweep	Zero frequency span with sweep time of 19 ms	V. axis deviation		Within ±0.2 div.	
				H. axis deviation		0-0.5 div.	
	20	Reference level variable range				More than 4 dB p-p	
	21	GP-IB check					
	22	Key operation check					
Performance test requiring measuring instruments	23	Sweep time accuracy		20 msec to 1000 sec		Within ±5%	
				100 µs to 1000 sec under zero frequency span		Within ±5%	
	24	TRIGGER		INTERNAL			
				LINE			
				VIDEO		Trigger point must be variable over 1 div.	
				EXTERNAL			
				SINGLE		Sweep only once upon each key operation	
	25	Center frequency accuracy				Within ±(1% of span ±20 Hz)	
	26	Vertical scale linearity	Logarithmic scale	In 0-0.8 dB range	0.1 dB/DIV	Within ±0.2 dB/1 DIV	
				In 0-95 dB range	1 dB/DIV	Within ±1 dB/1 DIV	
				In 0-95 dB range (20°C to 30°C)	10 dB/DIV	Within ±1 dB/1 DIV	
				In 0-95 dB range (0°C to 40°C)	10 dB/DIV	Within +1.5 dB/1 DIV	
			Linear scale			Within ±3% of the reference level	

		Test item			Specifications	Date
performance test requiring measuring instruments	27	Reference level accuracy			Within ±1.0 dB	
	28	Frequency response		Between 50 Hz and 1 GHz	Within 2 dBp-p	
				Between 50 Hz and 1.8 GHz	Within 3 dBp-p	
				Between 400 kHz and 1.8 GHz after error correction	Within ±0.7 dB	
	29	Spurious response	2nd harmonic	CF 20 MHz with -10 dBm input	Less than -60 dB	
				CF 20 MHz with -10 dBm input	Less than -45 dB	
			Two-signal distortion	Separation > 5 MHz with -10 dBm two signals	Less than -50 dB	
				Separation ≤ 5 MHz with -10 dBm two signals	Less than -45 dB	
	30	Gain compression		Under 0 dBm input with Input ATT. set at 0 dB	Less than 1 dB	
	31	Input ATT. switching accuracy		Over 0 to 50 dB at 50 MHz	Within ±0.5 dB	
	32	CAL. signal level accuracy		$20-30^{\circ}C$	Within -20 dBm ±0.3 dB	
T.G. performance test	33	T.G. output level accuracy		At 50 MHz output frequency	Within 0 dBm ±1.0 dB	
	34	TG output freq. response	With reference to 50 MHz output freq. with TG ATT. set at 10 dB	Over 400 kHz to 1500 MHz	Within ±0.7 dB	
				Over 400 kHz to 1800 MHz	Within ±1 dB	
	35	TG attenuator switching accuracy		0-50 dB at 50 MHz	Within ±0.5 dB	

		Test item			Specifications	Date
T.G. performance test	36	TG output spurious	Higher harmonics		Less than -20 dB	
			Non-harmonics	400 kHz-1500 MHz	Less than -30 dB	
				1500 MHz-1800 MHz	Less than -25 dB	
			Non-harmonics that cross the fundamental wave	400 kHz-1800 MHz	Less than -30 dB	
	37	TG freq. tracking (drift)	In 1 min		Less than 30 Hz	
			In 10 min		Less than 300 Hz	
	38	TG signal leakage	0-1500 MHz		Less than -100 dBm	
			0-1800 MHz		Less than -95 dBm	
Phase, Group Delay performance test	39	Phase display range accuracy	In each display range		Within ±180 ±5 deg.	
	40	Phase offset variable range			More than ±250 deg.	
	41	Group delay offset variable range			More than 3600 deg.	
	42	Group delay offset variable range			Within 50.6 ±2.5 deg.	
	43	Group delay display range accuracy	At freq. span of 10 MHz with 40 deg/div.		Within ±3%	
	44	Phase stability	Freq. span 10 MHz, Resolution BW 100 kHz, Video BW 30 kHz, and within 100 ms		Within 0.1 deg. p-p	
	45	Supply voltage variation	For 100 Vac		±10%	
			For 240 Vac		+4%, -10%	

WARRANTY

Takeda Riken product is warranted against defects in material and workmanship for a period of one year from the date of delivery to original buyer.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by buyer, unauthorized modification or misuse, accident or abnormal conditions of operations.
No other warranty is expressed or implied. Takeda Riken specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.
Takeda Riken shall not be liable for any special incidental or consequential damages, whether in contract, tort or otherwise.

SERVICE

During the warranty period, Takeda Riken will, at its option, either repair or replace products which prove to be defective.
When trouble occurs, buyer should contact his local supplier or Takeda Riken giving full details of the problem and the model name and serial number.
For the products returned to Takeda Riken for warranty service, buyer shall prepay shipping and transportation charges to Takeda Riken and Takeda Riken shall pay shipping and transportation charges to return the product to buyer. However, buyer shall pay all charges, duties, and taxes incurred in his country for products returned from Takeda Riken.
Repair service and supply of repair parts for a product purchased from Takeda Riken is guaranteed for 7 (seven) years.

CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL BUYER

The product should be throughly inspected immediately upon original delivery to buyer. All material in the container should be checked against the enclosed packing list or the instruction manual alternatively. Takeda Riken will not be responsible for shortage unless notified immediately.
If the product is damaged in any way, a claim should be filed by the buyer with carrier immediately. (To obtain a quotation to repair shipment damage, contact Takeda Riken or the local supplier.) Final claim and negotiations with the carrier must be completed by buyer.

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